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THE AMERICAN
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VOL. 104 FEBRUARY, 1932 NO. 2

EDITORIAL

THE MANDRAGORA

THIS IS the most famous plant in all history. From the dawn of mankind down to the present day, its annals appear in art, literature, science, medicine, pharmacy, legend and lore. Its story has been told in all languages, and has been known by all races of mankind.

In art, we see the mandrake in secluded recesses "glowing" at night. It is the "little gallows man" nourished by the drippings of the hanging criminal.

The root is dug during prayers, songs, incantations and ceremonials, with the aid of a dog, who perishes amid the "shrieks" of the plant as it is torn from the ground.

It is carved into the "male" and the "female" mandrake. The leaves become hair; the root-stalk is twisted and shaped into body, legs, arms, fingers and toes.

Kings and potentates cover the mandrake with rich clothes and place it in a shrine.

In astrology, the mandrake is placed under the dominion of the sun, moon or stars.

In legend and lore, no plant is invested with such marvelous attributes as pertain to the mandrake.

The good or the evil powers of the mandrake are governed either by the gods in the heavens or by the devils in hell. Beginning with the Biblical story of Rachel, the mandrake is a love charm and a stimulant to conception. It carries the power of transferring or turning away disease. It may bring good or bad luck. The marvelous magic powers of the mandrake fill the volumes. They enter into romance, poetry, song, story and dramatic literature.

But the mandrake is a Janus-like plant. Its story has two faces. In legend and lore we read of only one of its phases. It is legend and

lore that have given to the mandrake its sinister reputation. The superstitious side has obscured the true history and place of the mandragora in medicine. If we begin with the primitive medicine man, and trace our way through the annals of Egyptian, Greek and Roman medicine, and follow on through the centuries we will find that the mandragora fills a place in materia medica outrivaling that of any other drug, not excepting opium.

The mandragora is among the drugs used by Hippocrates (600 B. C.), the "father of medicine." Theophrastus, scientist and botanist, described it four centuries before our era. Pliny, naturalist and historian, writing in the days when Vesuvius buried Pompeii, recorded the preparation of the mandragora for use in medicine. The great Galen (second century, A. D.) records the medicinal uses of the mandragora in his many works. From Galen to the advent of the printed book, more than two score of notable medical works record pharmaceutical preparations in which the mandragora is a constituent.

After the middle of the fifteenth century came printed books. The Formularies or Recipe Books and the "Antidotaries" carried formulas containing the mandragora. The drug appears in the first "Pharmacopœia" of Valerius Cordus (1546) and follows through until toward the nineteenth century. These authorities enumerate a long line of pharmaceutical preparations in which the mandragora is a constituent. There are infusions, decoctions, wines, oils, cataplasms, clysters, ointments and plasters; there are pastes, electuaries and honeys; tablets, pills, confections and "antidotal" compounds for internal administration. The pharmacy of the mandragora forms a long and an interesting story.

The medicinal action and uses of the plant fill the annals. In medical literature the drug occupies its legitimate place. It is a narcotic solanum. Its soporific and anodyne action are fully recorded.

The medicinal uses named for the drug are numerous and extensive. It was applied externally for its anodyne, soothing and cooling effects. It was used in erysipelas and in maladies accompanied by inflammation. It was applied in eye troubles and to abscesses, indurations and tumors. Hippocrates stated its value for ulcers and wounds. Theophrastus noted its use in gout. Taken inwardly, it was employed for various ailments. It is mentioned as useful in different female troubles. Hippocrates notes its usefulness in curing "defluctions of humors." It was employed in mental disorders, especially "for those oppressed with melancholia."

Outstanding among the uses of the mandragora through the centuries is its place as an anæsthetic. It entered into an enormous number of anodyne compounds intended to relieve pain by causing sleep. It was almost the sole anæsthetic used in surgical operations up to the time of the advent of chloroform and ether. As a surgical anæsthetic, it was administered internally or applied to the part to be operated upon.

For upwards of sixty centuries the mandragora was used remedially for the same purpose for which, and in the same manner as, we now use anodyne drugs.

When men began to separate from plant drugs the bodies known as "alkaloids," it was found that the mandragora contained hyoscyamine, hyoscine, and a third alkaloid, the identity of which has not yet been determined.

At about the beginning of the seventeenth century the use of the mandragora as a remedial agent had declined. Finally it disappeared from the pharmacopœias and textbooks. To a limited extent, however, its use remains. In certain countries it is still employed as an anæsthetic in surgery. As late as 1895 preparations of this drug were noted in France as eligible remedies in pertussis. In regions around the Mediterranean, where it grows, it is used as a domestic remedy.

How can we account for the decline in the use of mandragora as a remedial agent? In part it was through the fact that belladonna and hyoscyamus, drugs similar in action, came into use and supplanted the use of the famous mandragora. In a larger part, however, its decline was brought about because, like the proverbial dog, the mandragora had received a "bad name." Through the ages, magic, superstition and legend became attached to the plant. It became a charm, a talisman, surrounded by legendary lore, which completely obscured its true place and character. Medicine, surgery and pharmacy simply abandoned it.

The mandragora is the Jekyll and Hyde of drugdom. Through many centuries, under the fostering care of Dr. Jekyll, it cured the ills of mankind. When the criminal fakir, Mr. Hyde, took it in hand it became the tool of the mountebanks and, in turn, the outcast of medicine.

The mandragora plant has not changed since the dawn. It will still quiet pain and put the fevered sick man to sleep. It will still relieve and help to cure the ills of humanity. If our narcotic, mydriatic solanums (belladonna, hyoscyamus, stramonium, etc.) were to be wiped from the face of the earth, the mandragora could fill their place.

Drugs that attain a high rank in one age become the laughing stock of later generations. A question here arises. In saying "pooh! pooh!" to some of our drugs because they have acquired a sinister reputation, perhaps we are discarding a valuable adjunct to our therapeutic armamentarium. There may be nuggets of gold among the "mandrakes" of the drug dump.

FRED. B. KILMER.

ORIGINAL ARTICLES

THE APOTHECARY, A LITERARY STUDY

By Edward Kremers

No. 42. Shakespeare's "Caitiff Wretch"

WHEN, at the request of the "City," Liebig, about the middle of the nineteenth century, spent some time in London to confer with the authorities about a more rational disposal of the sewage of the metropolis, he wrote home to his friend Woehler: "The chemists in England are no chemists at all, they are apothecaries."[1] This statement about the English "Chemist and Druggist"[2] is correct so far as Liebig had in mind the continental apothecary, with whom this *laissez faire* product of modern England is in a measure comparable. However, it is not correct so far as the English apothecary is concerned, for this professional character, separated from the grocer's guild by the charter of King James in 1617, hence a year before the London Pharmacopœia of the College of Physicians made its appearance and two years after the death of Shakespeare, was at the time Liebig wrote that of a medico-pharmaceutical practitioner. Whereas prior to 1665 his position was essentially that of the continental apothecary, his self-sacrificing acts as bedside practitioner during the Great Plague, when physicians as well as bishops fled from the stricken city,[3] made him the popular hero and secured for his calling popular recognition, his new hybrid character, however, caused him to occupy a position that but few would envy. This in spite of the fact that the calling boasted of such representatives as Theodore de Mayerne and Sir Hans Sloane. Indeed, the quarrel between the physician and his new rival was fought

[1] Liebig-Woehler, "Briefwechsel."

[2] Recognized officially as such by Act of Parliament. Since the World War the chemists of England have greatly resented what they regard as a misappropriation of their legitimate title by the "Chemist and Druggist" who, in turn, points to the parliamentary act as justification. This war over a title has been fought almost as bitterly in recent years as was fought the war over the privilege of bed side prescribing practiced by the apothecary after the Great Plague of 1665. The battle for the English chemist's prerogative has been taken up in this country, as it was foreshadowed by the remark of Liebig. The younger "chemists and druggists" of England appear to be willing to drop their official title and to designate themselves pharmacists, an attitude which is resented by some of the older representatives who desire to hold on to their traditional designation and official prerogative.

[3] Comp., *e. g.*, De Foe, "The Great Plague."

out, not only by pamphleteers of both professions,[4] but by Englishmen of letters as well.[5]

Shakespeare lived before this professional battle of letters was fought, yet his contempt for the apothecary, even before he had become the formidable rival of the physician, is clearly expressed in the delineation of one of the representatives of this calling in Romeo and Juliet. To the student of the apothecary in literature it may well seem doubtful which is the greater tragedy, that of the two lovers or that of the "caitiff wretch" whose poverty but not his will consents to the dispensing of that poison whose sale "is death to any he that utters them," and who is later betrayed to the minions of the law by Romeo, though, in receiving the coveted boon, the hero of the play utters: "I sell thee poison; thou hast sold me none."

Whereas it might prove interesting in this connection to trace briefly the history of the English apothecary, we are really less concerned with an accurate historical background than with the point of view of Shakespeare students and of other men of English letters. Hence, the following account of the apothecary taken from "Shakespeare's England" [6] would seem more apropos:

"I do remember an apothecary," says Romeo when in search of a poison, the sale of which in Mantua was prohibited on pain of capital punishment. He proceeds to a description of the shop and the wares of the thin poverty-stricken wretch:

> And in his needy shop a tortoise hung,
> An alligator stuff'd, and other skins
> Of ill-shaped fishes; and about his shelves
> A beggarly account of empty boxes,
> Green earthen pots, bladders, and musty seeds,
> Remnants of packthread, and old cakes of roses,
> Were thinly scatter'd to make up a show.
>
> (*Rom. and Jul.*, v. i, 42-8.)

The occupation was of long standing, but the English apothecaries did not receive a charter until 1607. This charter included the grocers, to whom Shakespeare makes no reference, but in the year of the poet's death James I granted a separate charter to the apothecaries—to their great satisfaction, as it gave them the right of controlling the purchase and sale of drugs and of searching grocers' shops. The charter thus mitigated the annoyance to which they were subjected by the special powers already conferred on the College of Physicians to over-

[4] As an illustration there may be cited "The Dispensary" of 1690, a poem published as a broadside by Sir Samuel Garth.

[5] None less than Pope, a friend of Garth, who sided with the physicians, thus expressed himself:

> "So modern 'pothecaries, taught the art
> By Doctors' bills to play the Doctor's part,
> Bold in the practicê of mistaken rules,
> Prescribe, apply, and call their masters fools."

[6] Vol. I, pp. 428-430.

haul the apothecaries' own stores for "evil and fawty stuffe." These powers and Romeo's speech show that the "evil stuffe" was that of which Harrison and Stubbes spoke in reference to the experiences of students in Italy. The apothecary had already been exhorted by Bullein "that he doe remember his office is onely to be the Physician's Coke" (Cook); and Cymbeline's queen puts herself in the apothecary's place when she says to Cornelius—

> Hast thou not learn'd me how
> To make perfumes? distil? preserve?
>
> (*Cymb.* I, v. 12-13.)

After the charter of 1616, trade disputes between the then separated apothecaries and grocers grew very frequent. Grocers might sell perfumes, but as they were excluded from the sale of drugs, it seemed hard that the apothecaries should be permitted to supply perfumes to their customers. It is to an apothecary that Lear appeals (Lear IV, vi, 133), not to grocer, for an ounce of civet, which he required as a scent and not as a drug.

Romeo's speech implies that many English sellers of drugs were starvelings and something worse, yet the apothecary in this country was as a rule a worthy man, though apt to make exorbitant charges.[8] There were several distinguished foreigners among the members of the "art and mystery" in London, such as Paul de Lobel, but unfortunately it was one of his assistants who, bribed by the jailer, administered to Sir Thomas Overbury the dose that killed him. There was no pharmacopœia in Shakespeare's lifetime; but the first London Pharmacopœia was in preparation, for it appeared in 1618. Among the physicians whose names are to be found in its pages is Harvey, styled "medicus regius iuratus."

That the apothecary as depicted by Shakespeare appealed to others is revealed rather strikingly by Otway[9] of whose *Caius Marius* Richardson[10] says that the apothecary was "borrowed from immortal Shakespeare." As to how correctly the term borrow was used the reader may judge for himself by a comparison of the texts from Shakespeare and Otway.

Shakespeare	Otway
Rom. . . . O mischief! thou art swift	*Mar. jun.* . . . Oh mischief! thou art swift
To enter in the thoughts of desperate men!	To catch the straggling thoughts of desp'rate men.
I do remember an apothecary,—	I do remember an apothecary,

[8] Scott, in "St. Ronan's Well" appears to be of a different opinion.

[9] Thomas Thornton, in "The Works of Thomas Otway," edited by him, London, 1813, makes the following statement as to "The history and fall of Caius Marius": "The greater part of this tragedy has been transferred from Shakespeare's 'Romeo and Juliet'; namely, the characters of Marius junior (Romeo), Lavinia (Juliet), Sulpitius (Mercutio), and the nurse: so that there will be little left from which Otway can derive any considerable merit as the author." To this list of "borrowed" characters the editor should have added that of the apothecary.

[10] Samuel Richardson, "Clarissa or the story of a young lady," 1748.

And hereabouts he dwells,—whom late I noted
In tattered weeds, with overwhelming brows,
Culling of simples; meagre were his looks,
Sharp misery had worn him to the bones;
And in his needy shop a tortoise hung,
An alligator stuffed, and other skins
Of ill-shaped fishes; and about his shelves
A beggarly account of empty boxes,
Green, earthen pots, bladders, and musty seeds,
Remnants of packthread, and old cakes of roses,
Were thinly scattered to make up a show.
Noting this penury, to myself I said—
And if a man did need a poison now,
Whose sale is present death in Mantua,
Here lives a caitiff wretch who would sell it him.
O, this same thought did but forerun my need;
And this same needy man must sell it me.
As I remember, this should be the house;
Being holiday, the beggar's shop is shut.—
What, ho! apothecary.

Enter Apothecary

Ap. . . . Who calls so loud?
Rom. Come hither, man.—I see that thou art poor;
Hold, there is forty ducats; let me have
A dram of poison; such soon-speeding gear
As will disperse itself through all the veins,
That the life-weary taker may fall dead;
And that the trunk may be discharged of breath
As violently, as hasty powder fired
Doth hurry from the fatal cannon's womb.
Ap. Such mortal drugs I have; but Mantua's law
Is death to any he that utters them.
Rom. Art thou so bare, and full of wretchedness,
And fear'st to die? Famine is in thy cheeks;
Need and oppression stareth in thy eyes;
That dwelt about this rendezvous of death:
Meagre and very rueful were his looks;
Sharp misery had worn him to the bones;
And in his needy shop a tortoise hung,
An alligator stuff'd, and other skins
Of ill-shap'd fishes: and about his shelves
A beggarly account of empty boxes,
Green earthen-pots, bladders, and musty seeds,
Remnants of pack-thread, and old cakes of roses,
Were thinly scatter'd to make up a shew.
Oh for a poison now! his need will sell it,
Tho' it be present death by Roman law.
As I remember, this should be the house.
His shop is shut: with beggars all are holidays.
Holla! Apothecary; hoa!

Enter Apothecary.

Apoth. Who's there?
Mar. jun. Come hither, man, I see thou'rt very poor;
Thou mayst do anything: here's fifty drachmas;
Get me a draught of that will soonest free
A wretch from all his cares; thou understandest me.
Apoth. Such mortal drugs I have, but Roman law
Speaks death to any he that utters them.
Mar. jun. Art thou so base, and full of wretchedness;
Yet fear'st to die? famine is in thy cheeks,
Need and oppression stareth in thy eyes,
Contempt and beggary hang on thy back;
The world is not thy friend, nor the world's law;
The world affords no law to make thee rich:
Then be not poor, but break it, and take this.
Apoth. My poverty, but not my will consents—

(Goes in and fetches a Phial of Poison.)

Upon thy back hangs ragged misery;
The world is not thy friend, nor the world's law.
The world affords no law to make thee rich;
Then be not poor, but break it, and take this.
Ap. My poverty, but not my will, consents.
Rom. I pay thy poverty, and not thy will.
Ap. Put this in any liquid thing you will,
And drink it off; and, if you had the strength
Of twenty men, it would despatch you straight.
Rom. There is thy gold, worse poison to men's souls,
Doing more murders in this loathsome world,
Than these poor compounds that thou mayst not sell.
I sell thee poison, thou hast sold me none.
Farewell; buy food, and get thyself in flesh.
Come, cordial; and not poison; go with me
To Juliet's grave, for there must I use thee.—(*Exeunt.*)

Take this and drink it off, the work is done.
Mar. jun. There is thy gold, worse poison to men's souls,
Doing more murders in this loathsome world
Than these poor compounds thou'rt forbid to sell.
I sell thee poison, thou hast sold me none.
Fare well—buy food—and get thyself in flesh.
Now for the monument of the Metelli.—(*Exit.*)

However, in spite of Otway's imagined improvement on Shakespeare's apothecary, he became a classic not only in English-speaking countries. Thus Phillippe in his "Histoire des Apothicaires" conveniently quotes Shakespeare in his introductory chapter. Always sarcastic, so far his account of the French apothecary before the Revolution is concerned, the description in "Romeo and Juliet" fits well into his scheme, whether it does justice to the French apothecary or not. As a matter of fact, for a true satirization of the French *apothicaire* the French physician ought to have drawn upon the dramas of his own countryman Molière, rather than upon the Bard of Avon. The development of pharmacy on the opposite sides of the channel was so different that Shakespeare's picture no more represents the French *apothicaire* than Molière's *Klistirschuetze* would be recognizable by the English theatre-goer.

As a text study Ludwig's German translation as well as Phillippe's original French text are herewith quoted:

"Shakespeare, qui naquit en 1562, nous dépeint ainsi la boutique des apothicaires anglais de son temps: 'Il y a par ici, je m'en souviens, un vieil homme qui vend des remèdes et fait de la chimie, un malheureux quej'ai remarqué; il cueillait des simples; il avait des sourcils touffus et quelques haillons sur le corps; il était maigre, on voyait ses os; la misère l'avait usé. Son squelette apparaissait dans sa boutique, sa pauvre boutique; une tortue et un serpent étaient suspendus avec quelques poissons de forme hideuse. Le misérable homme étalait, sur ses tablettes, je ne sais quels débris indigents qu'il essayait de faire valoir de son mieux: bouteilles vides, fioles brisées, graines desséchées, vieilleries sans nom; de petits pots de terre cuite; des boites dépareillées et vides.—Ah! quelle indigence! me dis-je an passant; si l'on voulait acheter du poison, voilà bien le repaire du pauvre gueux qui le vendrait, et la loi de Mantoue, qui punit de mort le coupable, ne l' effrayerait pas'!"

Romeo et Juliette, acte V, scene 1, *Les Pandectes,* p. 3.

Phillippe, *Histoire des Apothecaires,* p. 10.

"Shakespeare, geboren 1562, zeichnet uns die Kramladen der Apotheker seiner Zeit wie folgt: 'Es wohnt hier herum, ich erinnere mich dessen, ein alter Mann, der Heilmittel verkauft und sich mit Chemie abgiebt; ich habe den Ungluecklichen bemerkt; er sammelte[11] Kraeuter; er hatte dichte Augenbrauen und einige Lumpen auf dem Leibe; er war mager, man sah seine Knochen, das Elend hatte ihn aufgerieben. Sein Skelet erschien in seiner Boutique, seiner armen Boutique; eine Schildkroete und eine Schlange waren darin aufgehaenght, daneben hingen einige Fische von scheusslicher Gestalt. Der elende Mensch kramte auf seinen Tischchen, ich weiss nicht, welche duerftigen Truemmer aus, die er so gut als moeglich zu verwerthen versuchte: alte Flaschen, zerbrochene Phiolen, ausgetrocknete Samen, alten Kram ohne Namen, kleine Toepfe aus gebrannter Erde; Buechsen, vereinzelt und leer. —Ach! welche Duerftigkeit! sagte ich im Gehen zu mir selbst; wenn man Gift kaufen wollte, diese Hoehle des armen Bettlers wäre gewiss der Ort, wo man es bekaeme, und das mantuanische Gesetz, welches solchen Schuldigen mit dem Tode bestraft, wuerde ihn nicht abschrecken'."

Romeo und Julie, 5. Act, 1. Scene. *Pandecten,* S. 3.

Phillipe, Ludwig, *Geschichte der Apotheker,* p. 16.

As already pointed out, the parliamentary recognition achieved by the apothecaries does not appear to have assisted them to more favorable recognition by men of letters. As late as 1748 Richardson, in his "Clarissa," finds Shakespeare's characterization quite apropos and deliberately quotes the Bard of Avon in his description of another wretch of the profession. Though Richardson apparently did not have much love for the physician, he depicts the cringing apothecary as the more despicable of the two. But, let Richardson speak for himself:

[11] Shakespeare's "culling of simples" when translated via Phillippe's French version becomes "collecting (sammeln) of herbs." In a dictionary sense, the translation cannot be pronounced incorrect. However, the Mantuan apothecary could scarcely be collecting herbs in his city shop.

She was sitting on the side of the broken couch, extremely weak and low; and, I observed, cared not to speak to the man: and no wonder, for I never saw a more shocking fellow, of a profession tolerably genteel, nor heard a more illiterate one prate—physician in ordinary to this house, and others like it, I suppose! He put me in mind of Otway's apothecary in his "Casius Marius"; as borrowed from immortal Shakespeare:

> Meagre and very rueful were his looks:
> Sharp misery had worn him to the bones.
> —famine in his cheeks;
> Need and oppression staring in his eyes:
> Contempt and beggary hanging on his back:
> The world no friend of his, nor the world's law.

As I am in black, he took me, at my entrance, I believe to be a doctor; and slunk behind me with his hat upon his two thumbs, and looked as if he expected the oracle to open, and give him orders.

Of special interest are Dickens' references to Shakespeare's apothecary. Thus, "in a conversation between Dr. Jobling (who apparently received his name from his hiring out to do certain, not highly professional jobs for Mr. Montague and the Anglo-Bengalle Disinterested Loan and Life Insurance Company) and Jonas Chuzzlewit over a glass of wine at a private luncheon in the office of the insurance company, the former makes the following statement:

Your bosom's lord sits lightly on his throne, Mr. Chuzzlewit, as what's-his-name says in the play.[12] He concludes his reference with the following sentences: I wish he said it in a play which did anything like common justice to our profession, by-the-by. There is an apothecary in that drama, Sir, which is a low thing: vulgar, Sir, out of nature altogether.

It has been pointed out that in his "Mantuan" apothecary, Shakespeare cannot be said to do justice to the Italian fraternity. Reference may be had to the edicts of Frederick II as far back as the thirteenth century which strictly regulated the pharmaceutical profession, placing it on at least a semi-independent footing. It should be recalled, however, that these edicts had but local significance and that hence their enforcement depended entirely upon local conditions which naturally varied with both time and place.

That even in the nineteenth century, the position of the Italian physician, as well as that of his colleague the apothecary, could be miserable indeed is revealed in Dickens' "Pictures From Italy." Thus in the chapter on "Genoa and its neighborhood," he renders the following "beggarly account" of "poor physicians" whose advertisement of their

[12] Apparently an adaptation of "My bosom's lord sits lightly in his throne." (Act V, Se. I, line 3.)

profession consists in lounging in the apothecary shop hoping that some misery may turn up to the advantage of their pocketbook.

> Most of the apothecaries' shops are great lounging places. Here, grave men with sticks, sit down in the shade for hours together passing a meagre Genoa paper from hand to hand, and talking, drowsily and sparingly, about the News. Two or three of these are poor physicians, ready to proclaim themselves on an emergency, and tear off with any messenger who may arrive. You may know them by the way in which they stretch their necks to listen, when you enter; and by the sigh with which they fall back again into their dull corners, on finding that you only want medicine. Few people lounge in the barbers' shops; though they are very numerous, as hardly any man shaves himself. But the apothecary's has its group of loungers, who sit back among the bottles, with their hands folded over tops of their sticks. So still and quiet, that either you don't see them in the darkened shop, or mistake them—as I did one ghostly man in bottle-green, one day, with a hat like a stopper—for Horse Medicine.[13]

In his chapter on "Verona, Mantua and Milan," the home of Shakespeare's "wretch," he makes the following allusion to this poor representative:

> If ever a man were suited to his place of residence, and his place of residence to him, the lean Apothecary and Mantua came together in a perfect fitness of things. It may have been more stirring then, perhaps. If so, the Apothecary was a man in advance of his time, and knew that Mantua would be, in eighteen hundred and forty-four. He fasted much, and that assisted him in his foreknowledge.[14]

Hence one need not be surprised at Stephen's modern version of the Mantuan apothecary in "Paolo and Francesca."[15] After all, Shakespeare may not have done so great an injustice to our Italian colleague of the fifteenth century, though his prototype, no doubt, was English, or rather French. English in the sense that Shakespeare knew neither the Italian nor the French apothecary, French in the sense that it is in the French version that we first find this character.

Though the apothecary scene affords an effective diversion on the stage, the central motive of the story of the two lovers is the drug simulating death without killing. Pharmaceutically, this is as interesting as the poison dispensed by the apothecary, though it is a monk who possesses its secret. As a matter of fact, the early versions contain no apothecary whatever. Hence it may not be amiss to trace the appearance of the apothecary upon the scene.

The first to weave the ancient legend of the unfortunate lovers into a modern story (*Il novellino*) was Tommaso Masuccio of Salerno

[13] Dickens, *Pictures from Italy*, p. 42.
[14] *Ibid.*, p. 89.
[15] See "The Apothecary in Literature," No. 6. *Med. Dr. and Ph. Rev.* 45, p. 5.

in the fifteenth century, one of whose five books of novelettes is entitled "Mariotto and Giannozza."

Having enjoyed each other's company in secret, Mariotto is involved in a street quarrel and strikes his antagonist with his cane. Death results after several days, and Mariotto escapes justice from Siena, his home, to Alexandria. Giannozza is urged to marry and finally consents, only to seek relief from the intolerable situation by taking a potion that produces a three-day sleep sembling death. She is buried but rescued from the grave by the monk whose advice she has followed. Dressed as a man, she also goes to Alexandria, only to learn that her lover has left for Siena upon the news of her death. While prying open the mausoleum in order to die at his sweetheart's side, he is discovered, recognized, condemned, and duly beheaded. Giannozza retreats her steps and arrives three days after the execution. She is taken to a convent and soon dies from grief over her unlucky fate.

In all of the versions it is a monk whose advice the unfortunate young woman seeks and who is in possession of the secret knowledge of the strange preparation. In this instance it is the same monk who has performed the marriage ceremony kept secret from the parents. Reluctant and timid at first,

> Dann aber hielt er ihr die Vorzuege und den Zauber des heiligen Giovanni Boccadoro vor, wodurch er kuehn und stark wurde, so dass er mit Mannhaftigkeit das Unternehmen durchfuehren wollte. Wegen der Not, die sie bedraengte, ging der Moench alsogleich fort und—weil in dieser Sache wohlerfahren—bereitete er selber durch besondere Mischung unterschiedlicher Pulver einen Trank von solcher Wirkung, dass Giannozza, wenn sie ihn getrunken haette, nicht nur drei Tage hindurch schlafen, sondern auch von jedermann fuer tot gehalten wuerde. Und er schickte ihn der Frau.
>
> . . . . nachdem sie vom Moenche die Anweisung fuer ihr Verhalten empfangen hatte, trank sie mit grosser Freude jenen Trank. Nicht lange darauf ueberkam sie eine so grosse Erstarrung, dass sie wie tot zu Boden fiel. . . . In hoechster Eile liess er (der Vater) Aerzte rufen, um sie mit allen Mitteln wieder zum Leben zu bringen; doch da keines half, waren alle der Ueberzeugung, sie waere am Schlagfluss gestorben. . . . So wurde sie . . . am folgenden Tage bestattet.
>
> Der Uebereinkunft gemaess wurde sie um Mitternacht von dem ehrwuerdigen Moenche unter Beihuelfe eines seiner Mitbrueder aus der Gruft herausgeholt und in seine Zelle gebracht. Und da die Stunde nahte in der die Wirkung des Trankes sich erschoepfte, wurde sie durch Feuer und andere nothwendige Mittel mit groester Muehe wieder zum Leben erweckt.[16]

[16] The German translation is that of Rudolf Fischer, of the University of Innsbruck, as it appears in "Shakespeare's Quellen in der Originalsprache und deutsch herausgegeben im Auftrage der Deutschen Shakespeare-Gesellschaft. 2. Baendchen. *Romeo u. Julia,*" pp. 5 and 6. (A. Marcus and E. Weber's Verlag, Bonn, 1922.)

As already pointed out, Mariotto seeks death, but not through poison or stiletto. How he finds it has already been related. Hence this story is not in need of an apothecary, though, like all others, it involves a monk with secret medical knowledge. Masuccio, the author, lived in Salerno. It will be remembered Salerno was a famous medical centre, indeed the parent institution of the medical schools of Europe.

The short story of Masuccio was materially expanded into his novel, "Giulietta," by Luigi da Porto in 1524. He claims to have heard it in Verona.[17] The actors have become members of the nobility of that city. The hero and heroine have been secretly married by Brother Lorenzo, a Franciscan monk, but had to separate because of a street brawl in which Romeo had been involved. Again, Juliet is to be married by her father, but escapes by taking the potion given to her in powder form by her father confessor. Having determined to take poison, if necessary, she resolves to see Father Lorenzo, a protege of Romeo, of whom she has heard that he can accomplish the miraculous. So she asks permission to make confession in order that, at Easter time, she "zur Heilung meiner Schmerzen die liebliche Arznei des geheiligten Leibes unseres Herrn empfangen moege." [18]

Asked for poison, the monk finally says:

> Gift geb ich dir nicht, mein Kind, es waere zu grosse Suende, wenn du so jung und schoen stuerbest; wenn du dich aber entschliessen kannst, zu thun, was ich dir sage, so gebe ich dir mein Wort, dass ich dich sicher zu deinem Romeo bringe. Du weisst, dass die Gruft von Euch Capelletti sich vor dieser Kirche auf unserem Friedhofe befindet. Ich werde dir ein Pulver geben: wenn du das nimmst, wirst du auf achtundvierzig Stunden oder wenig mehr oder minder in solchen Schlaf sinken, dass jedermann, und wen es der groesste Arzt waere, dich fuer nichts anders als tot halten wird, etc.[19]
>
> Mit diesen Worten verliess der gute Moench . . . den Beichtstuhl, ging in seine Zelle und kam mit einem kleinen Flaeschchen Pulver zurueck und sprach: "Nimm dies und trinke es, wenn es dich gut duenkt, unbesorgt, etwa nachts zwischen drei und vier Uhr, in frischem Wasser. Gegen sechs wird es zu wirken anfangen und" . . .[20]

She returns home in good cheer and later drinks the powder in water in the presence of her maids, who suspect nothing until the next morning when they find her apparently dead, fully dressed, on her bed. Suicide is suspected, and even the physician declares her dead.

[17] In Giralamo de la Corte's "History of Verona," published in Venice in 1549, Luigi da Porto's novel "is given and stated to be a true story." C. & D. 1908, I, p. 15.

[18] Rudolph Fischer, *l. c.*, p. 22.

[19] *Ibid.*, p. 22.

[20] *Ibid.*, p. 23.

When Romeo, failing to receive her letter of explanation, hears of her death, he is ready to commit suicide, but is prevented. Taking with him a phial of snake poison, he returns to Verona, opens the grave, lies down next to his bride, and after much lamentation takes the fatal dose. This, however, acts slowly enough to enable Juliet to awake and to recognize her lover. Realizing their situation, they lament their fate. Meanwhile Father Lorenzo has come to rescue Juliet from the grave and is surprised to see it open and a light in it. More lamentation, and the death of Romeo follows. Juliet refuses to leave the grave and chokes herself by holding her breath. Then follows the discovery, ending in peace between the two rival houses.

The dominican Matteo Bandello, a professional story writer who published his collection of 214 stories in three volumes in 1554, enlarged upon the story of Luigi. Hence repetition is unnecessary. Himself a monk, the author describes Father Lorenzo's attainments in the following words:

> Bruder Lorenzo war ein sehr grosser Experimentenmacher, der zu seiner Zeit sehr viele Laender bereist und sich ein Vergnuegen daraus gemacht hatte, mancherlei Dinge zu versuchen und zu lernen; und vor allem kannte er die Kraefte der Kraeuter und Steine und war einer der groessten Scheidekuenstler, die zu jener Zeit lebten. Unter andern wusste er gewisse schlaferrengende Bestandtheile zu mischen und einen Teig daraus zu kneten, aus welchem er dann ein feines Pulver von wunderbarer Kraft bereitete.[21] Wer es mit ein wenig Wasser vermischte und trank, den versenkte es binnen einer oder zwei Viertelstunden in einen so festen Schlaf, betaeubte seine Lebensgeister und richtete ihn dergestalt zu, dass kein Arzt, so gelehrt und erfahren er auch sein mochte, ihn nicht fuer tot gehalten haette. In diesem suessen Tode hielt es den, der es getrunken hatte, wenigstens vierzig Stunden oder laenger befangen, nach Massgabe der groesseren oder geringeren Dosis, welche er davon nahm, und des Temperaments des Trinkers. Nachdem aber das Pulver seine Wirkung getan hatte, erwachte er, nicht anders als aus einem langen suessen Schlaf, und fuehlte nichts von Beschwerde oder schaedlicher Nachwirkung.[22]

Unable to persuade Juliet not to flee to Romeo or to commit suicide, the monk finally proposes his well-known solution of the difficulty.

> Der Bruder lief rasch in seine Kammer und brachte Julien etwa einen Loeffel voll dieses Pulvers, in ein wenig Papier eingewickelt.[23]

This third story also knows no apothecary. Romeo has recourse to a "Flaeschen, dass mit einem sehr giftigen Safte gefuellt war"[24]

[21] One may be inclined to see in this description an allusion to the preparation of so-called gum opium and its powder.

[22] Rudolph Fischer, *l. c.*, p. 53.

[23] *Ibid.*, p. 55.

[24] *Ibid.*, p. 62.

such as men of distinction seem to have been provided with for emergencies in those days, just as Romeo wore a metal armor while going about the city as a protection in street brawls. The nature of the poison receives next to no attention. Many potent poisons were undoubtedly known and used, hence called for no special comment, as did the sleep-producing potion of the monk. In the suicidal act itself the contents of the phial are referred to as "das giftige Wasser." [25] He himself then alludes to it as "Schlangengift . . . welches . . . kaum eine Stunde braucht um zu toeten." [26]

Snake poisons, however, are not necessarily poisonous to the stomach. Hydrocyanic acid, or *Aqua Lauro-cerasi* or *Aqua Amygdalarum amararum* are more likely to conform to the description "das giftige Wasser," both being distilled waters.

Schau hier das Flaeschchen, worin das Wasser war, welches dir, wenn du dich erinnerst, jener Spoletiner in Mantua gab, der die lebenden Nattern und Schlangen zeigte. . . . ich fuehle den nahenden Tod: das Gift des toedlichen Wassers rinnt schon verzehrend durch alle meine Adern.[27]

Boisteau, in his "Histoires tragiques," 1559, paved the way for the story into England. The French quite generally served as intermediaries in making the productions of the Italian Renaissance available to England. He was a mere translator but not a literal one, for he did not disdain to make additions of his own. This is noticeable in several instances. To the pharmaceutical student it is of special interest to note that he is the first to introduce the apothecary.

The story of the monk is much the same, only he is allowed to sing his own praise:

Du weisst . . . dass ich fast alle Laender der bewohnten Erde bereist . . . Und doch, meine Tochter, war all mein Wandern nicht unnuetz . . . denn . . . habe ich hiebei noch eine andere, besondere Frucht eingesammelt, welche du mit Gottes Gnade in kurzem mitgeniessen wirst. Ich habe die geheime Eingenart von Steinen, Pflanzen, Metallen erprobt . . . und . . . weiss ich sie mir zu nuetzen. . . . Hoere also, meine Tochter: nebst anderem . . . habe ich seit langem die Herstellung eines Teiges gelernt und erprobt, den ich aus gewissen, einfachen Schlafmitteln bereite. Wenn man den Teig hinterher zu Pulver zerreibt und dieses mit ein wenig Wasser trinkt, schlaefert es den, der es nimmt, so sehr ein und versenkt ihm seine Sinne und Lebensgeister so tief, dass kein Arzt, und waere er noch so ausgezeichnet, den nicht fuer tot erkaennte, der es genommen. Ueberdies hat das Pulver eine Wirkung noch wundervoller: wer es nimmt fuehlt keinen Schmerz und entsprechend der Menge, in der er es genommen, verbleibt er in diesem suessen Schlummer; ist aber die Wirkung vorueber, so kehrt er zu seinem frueheren Zustand zurueck.[28]

[25] *Ibid.*, p. 63.
[26] *Ibid.*, p. 63.
[27] *Ibid.*, p. 63.
[28] *Ibid.*, p. 95.

Having been informed of Juliet's death by his servant, Romeo makes a search in Mantua for the remedy he desires:

> Nachdem er unter andern den Laden eines Apothekers bemerkt hatte, der recht schlecht ausgestattet war mit Flaschen und den sonstigen hierhergehoerigen Sachen, dachte er bei sich selbst, dass den Besitzer seine bittre Armut gern dem zustimmen lassen wuerde, worum er ihn ersuchen wollte. Er zog ihn zur Seite und sagte insgeheim zu ihm:
>
> "Meister, da sind fuenfzig Dukaten die ich Euch gebe, und gebt mir irgendein starkes Gift, das den, der es nimmt, in einer Viertelstunde toetet."
>
> Der arme Teufel—von Habgier besiegt—stimmte dem bei, worum ihn jener ersucht hatte. Indem er vor den Leuten so that, als gaebe er ihm irgendein anderes Heilmittel, bereitete er ihm sofort das Gift und sagte ihm dann ganz leise:
>
> "Monseigneur, ich gebe Euch hievon mehr, als Ihr braucht, denn schon die Haelfte genuegt, um in einer Stunde den staerksten Mann der Welt umzubringen." [29]

A third point of pharmaceutical interest in the story is that Romeo, in advising his father by letter of his intentions, also goes out of his way to state where he secured the poison with which he intends to commit suicide. Whereas Father Laurens in his confession states:

> Ferner und schliesslich sei er (obwohl er in Hinblick auf sein Alter und seinen Tod entschlossen war, alle Geheimwissenschaft zu verabscheuen, an der er sich in jungen Jahren ergoetzt hatte) sei er trotzdem von der Wichtigkeit des Falles und von seinem Mitleid gedraengt worden . . . Juliette ein Schlafpulver zu geben . . .[30]

And is pardoned, and Pierre, Romeo's servant and other participants are allowed to go scot free, the apothecary meets with a different fate: "der Apotheker wurde gefangen, gefoltert und als uebergefuehrt gehenkt." [31]

Luigi's story was also translated into English:[32] the one in rhyme by Arthur Brooke appeared in 1562, the prose translation by Painter later. Inasmuch as it is from Brooke's version that Shakespeare took "not only the incidents . . . but . . . some of his expressions" as well, it is this version which is of special interest to us. It is entitled "The tragical historie of Romeus and Juliet." "Brooke describes Romeus in Mantua, resolved to die, and looking for a shop where he may buy poison."

[29] *Ibid.*, p. 101.

[30] *Ibid.*, p. 107.

[31] *Ibid.*, p. 108.

[32] According to Rudolf Fischer the sequence is somewhat different, *viz.*, as indicated: Masuccio, Luigi da Porta, Bandello, Boisteau, Painter, Brooke, Shakespeare; *l. c.*, p. VII.

Straight, weary of the house, he walketh forth abroad;
His servant, at the master's hest, in chamber still abode;
And then fro street to street he wand'reth up and down,
To see if he in any place may find, in all the town,
A salve meet for his sore, an oil fit for his wound;
And seeking long—alack, too soon!—the thing he sought, he found.
An apothecary sat unbusied at his door,
Whom by his heavy countenance he guessed to be poor.
And in his shop he saw his boxes were but few,
And in his window, of his wares, there was so small a shew;
Wherefore our Romeus assuredly hath thought,
What by no friendship could be got, with money should be bought;
For needy lack is like the poor man to compel
To sell that which the city's law forbiddeth him to sell.
Then by the hand he drew the needy man apart,
And with the sight of glitt'ring gold inflam'ed hath his heart:
"Take fifty crowns of gold," quoth he, "I give them thee.
So that, before I part from hence, thou straight deliver me
Some poison strong, that may in less than half an hour
Kill him whose wretched hap shall be the potion to devour."
The wretch by covetise is won, and doth assent
To sell the thing, whose sale ere long, too late, he doth repent
In haste he poison sought, and closely he it bound,
And then began with whispering voice thus in his ear to round:
"Fair sir," quoth he, "be sure this is the speeding gear,
And more there is than you shall need; for half of that is there
Will serve, I undertake, in less than half an hour
To kill the strongest man alive; such is the poison's power."
Then Romeus, somewhat eased of one part of his care,
Within his bosom putteth up his dear unthrifty ware.[33]

For the sake of completeness, Painter's prose version may here be quoted:

. . . hee wente out of his Chamber, and commaunded hys man to tarry behynd him, that he myght walke through out all the Corners of the Citye, to finde propre remedye (if it were possyble) for hys gryefe. And amonges others, beholdynge an Apoticarye's shop of lyttle furnyture and lesse store of Boxes and other thinges requisite for that scyence, thought that the verye pouerty of the mayster Apothecarye would make hym wyllingle yeld to that which he pretended to demaunde: and after he had taken hym aside, secretly sayde unto him: "Syr, if you be the Mayster of the House, as I thynk you be, beholde here Fifty Ducates which I gyue you to the intent you delyuer me some strong and vyolente Poyson that within a quarter of an houre is able to procure Death unto hym that shall use it." The couetous Apothecarye entysed by gayne, agreed to his request, and faynying to gyue hym some other medycine before the People's Face, he speedily made ready a strong and cruell Poyson, afterwardes he sayd unto him softly: "Syr, I guye you more than is needefull, for the one halfe is able to destroy the strongest manne of the world:" who after he hadde receyued the poyson, retourned home. . . .[34]

[33] Arthur Brooke, *Romeus and Juliet*, p. 95.

[34] "The Palace of Pleasure. Elizabethan versions of Italian and French Novels from Boccaccio, Bandello . . . and others." Done into English by William Painter. Now again edited for the fourth time by Joseph Jacobs, London, 1890, vol. III, p. 115.

Also for the sake of completeness it may not be amiss to compare Shakespeare's text of 1597 with that of 1609 with which the modern reader is more familiar. By way of comment Wootton's remarks may here be quoted:

"Shakespeare was a busy man in 1597, and in the years before as well as about that date he was preparing novelties for his theatre. Later he had more leisure, and it is interesting to notice how artistically he fills out his original sketch with only just such details as make the ideas more vivid. In the revised version of this scene, published in 1609, there are no new ideas, but scarcely a line is left untouched. A comparison of title-pages in the two editions is amusing and at the same time instructive. In 1597 it reads: 'An Excellent Conceited Tragedie of Romeo and Juliet as it hath been often (with great applause) plaid publiquely.' In 1609 this is toned down to 'The most Excellent and Lamentable Tragedie of Romeo and Juliet as it hath been sundri times publiquely Acted.' The omission of the parenthetic ('with great applause') is significant. The poet knows he no longer needs meretricious advertisement."[35]

FIRST QUARTO EDITION, 1597

Rom. As I do remember
Here dwells a pothecarie whom oft I noted
As I past by, whose needie shop is stuft
With beggarly accounts of empty boxes.
And on the same an Aligarta hangs,
Olde ends of packthred, and cakes of roses
Are thinly strewed to make up a show.
Here as I noted thus with myselfe I thought:
Ah, if a man should need a poison now,
(Whose present sale is death in Mantua),
Here he might buy it. This thought of mine
Did but forerune my need; and hereabout he dwells.
Being holiday the beggar's shop is shut.
What ho! Apothecary! Come forth I say.
Ap. Who calls? What would you, Sir?

THIRD QUARTO EDITION, 1609.

Rom. I do remember an apothecary
And hereabouts he dwells—whom late I noted
In tatter'd weeds, with overwhelming brows,
Culling of simples; meager were his looks,
Sharp misery had worn him to the bones;
And in his needy shop a tortoise hung,
An alligator stuff'd, and other skins,
Of ill-shap'd fishes; and about his shelves
A beggarly account of empty boxes,
Green earthen pots, bladders, and musty seeds,
Remnants of packthread, and old cakes of roses,
Were thinly scatter'd to make up a show.
Noting this penury, to myself I said—
And if a man did need a poison now,
Whose sale is present death in Mantua,
Here lives a caitiff wretch would sell it him.

Also "An Elizabethan Story-Book," by Peter Fanworth, London, 1928, p. 62.

Compare also "The Apothecary in Romeo and Juliet," by Xrayser, under "Observations and Reflections." C. & D., Jan. 4, 1908, p. 15; also Dec. 28, 1907, p. 969.

[35] A. C. Wootton, *Chronicles of Pharmacy*, vol. II, p. 79. In this connection it may not be amiss to quote from a review of E. K. Chambers, William Shakespeare. A study of facts and problems ". . . that the great majority of plays are Shakespeares from beginning to end, and that, broadly speaking, when he had once written them, he left them alone." *The Nation*, 132, p. 19.

Rom. Here's twenty ducats.
Give me a dram of some such speeding gere
As will despatch the weary taker's life
As suddenly as powder being fired
From forth a cannon's mouth.
Ap. Such drugs I have, I must of force confesse,
But yet the law is death to those that sell them.
Rom. Art though so bare and full of poverty,
And dost thou fear to violate the law?
The law is not thy friend nor the law's friend?
And therefore make no conscience of the law.
Upon thy back hangs ragged misery
And starved famine dwelleth in thy cheeks.
Ap. My poverty but not my will consents.
Rom. I pay thy poverty but not thy will.
Ap. Hold, take you this and put it
In any liquid thing you will, and it will serve
Had you the lives of twenty men.
Rom. Hold, take this gold, worse poison to men's souls
Than this which thou hast given me.
Go hie thee hence,
Go, buy thee cloathes, and get thee into flesh
Come cordial and not poison, go with me
To Juliet's grave, for there must I use thee.

O, this same thought did but forerun my need;
And this same needy man must sell it me.
As I remember this should be the house; being holiday, the beggar's shop is shut—
What ho! Apothecary!
Ap. Who calls so loud?
Rom. Come hither, man. I see that thou art poor;
Hold, there is forty ducats; let me have
A dram of poison; such soon speeding gear
As will disperse itself through all the veins,
That the life-weary taker may fall dead;
And that the trunk may be discharg'd of breath
As violently as hasty powder fired
Doth hurry from the fatal cannon's womb.
Ap. Such mortal drugs I have; but Mantua's law
Is death to any he that utters them.
Rom. Art thou so bare, and full of wretchedness,
And fear'st to die? famine is in thy cheeks.
Need and oppression starveth in thy eyes,
Contempt and beggary hangs upon thy back,
The world is not thy friend, nor the world's law;
The world affords no law to make thee rich;
Then be not poor, but break it, and take this.
Ap. My poverty but not my will consents.
Rom. I pay thy poverty and not thy will.
Ap. Put this in any liquid thing you will
And drink it off; and if you had the strength
Of twenty men, it would despatch you straight.
Rom. There is thy gold, worse poison to men's souls
Doing more murders in this loathsome world
Than these poor compounds that thou may'st not sell.

I sell thee poison, thou hast sold me none.
Farewell; buy food, and get thyself in flesh.
Come cordial, and not poison; go with me
To Juliet's grave, for there I must use thee.
Chronicles of Pharmacy, Vol. II, pp. 81-82.

To the student of the history of pharmacy, as it is reflected in Shakespeare's drama, there are three aspects of special interest:

(1) The sleep-producing drug given Juliet by the friar.

(2) The poison with which Romeo commits suicide.

(3) The fate of the apothecary.

Each of these is deserving of consideration.

It has already been intimated that the early Italian versions of "Romeo and Juliet" are of interest to the pharmaceutical student though the character of apothecary be absent. The sleeping potion given by the friar to Juliet and the poison with which Romeo commits suicide interest us even though not prepared by an apothecary.

As a matter of historic fact, at the time at which the story of the two ill-fated lovers became a motif for literary productions, public apothecary shops were few and far between even in Italy. It was an Arabic institution imported from Bagdad, presumably via Spain or possibly Carthage. It was at Salerno that Arabic and Greek medicine first blended. Naturally, it fructified monkish medicine as well. As a result the *Civitas Hippocratica* became the mother of the medical faculties of Europe. Yet about the same time that the Emperor Frederic II issued an edict (or possibly a series of edicts) that prohibited the financial collusion between physician and pharmacist, a pope forbade the practice of medicine and surgery by the monks. Whether this was done to appease the physicians or whether the pope saw too close a connection between medicine (including pharmacy) and the secret science of alchemy does not seem to become evident. This much, however, is apparent from one of the Italian precursors of Romeo and Juliet: Friar Laurenzo, who in his "Wanderjahre," in other words in his young manhood, had been intensely interested in the sciences of his day, abjures all further inclination in this direction when he is pardoned for his offense. It should scarcely be necessary to point out that the philosopher's stone, the tincture, the elixir, were

of equal interest to the physician and the alchemist; to the former as a means for curing disease, to the latter as a means to bring about transmutation.

The sleep-producing drug given Juliet by the Friar. In the story of Masuccio of Salerno, the monk prepared a draught by mixing several powders. Luigi da Porto has the monk give the distracted Giulietta a small "vial" of a "powder" which she is to drink in "fresh water." Matteo Bandelo informs the reader that Brother Lorenzo knew, among other things, how to mix certain sleep-producing substances to a "dough" from which he then prepared a "fine powder of miraculous power" which was to be mixed with a little water and drunk. According to this author, the monk delivers the powder to Juliet, "about a spoonful wrapped in a small paper."

Boisteau, who as translator acted as intermediary between the Italian precursors and Englishmen of letters, repeats practically the story of Bandello.

Shakespeare is rather noncommittal as to the preparation of the somniferent. The friar simply tells Juliet, "Take thou this phial . . . And this distilled liquor drink thou off"; and then discourses more at length on the qualities of the potion, a recital that affords by far greater dramatic effect than the statement that certain simples may be mixed to a dough and then reduced to a fine powder. The words "distilled liquor" also are more likely to appeal to the imagination of the hearer who seeks no scientific explanation. The words "dough" and "powder" are more suggestive of opium and a possible therapeutic explanation whereas "distilled liquor" completely eliminates opium or any of its preparations. Schelenz [36] states that no modern pharmacologist would venture to make promises like those made by the friar to Juliet. He might have added that no medical historian would venture to guess what "distilled liquor" might be supposed to produce the effect described. Certainly it was not his knowledge of medicine that caused Shakespeare to change the "dough" and "powder" of his precursors into a "distilled liquor," but it was his appreciation of what would be more effective on the stage.

It is but natural that pharmacists should speculate about the nature of this preparation. Thus F. Pilkington Sargent and J. H. Beacock [37]

[36] "Schlaf und todbringende Mittel in Shakespeare's Dramen," Separat-Abdruck aus d. *Klinisch-Therapeut. Wochenschr.*, Nr. 35, 1912, p. 2.

[37] "The Chemist and His Wares in Shakespeare's Time." *Western Druggist*, 32, p. 365; from *Pharm. Jour.*, 1910.

indulge in the following explanation: "In 'Romeo and Juliet' the effects of the draught which the friar gives to Juliet are described, and it suggests the idea of some preparation of opium. Slowness of the pulse, retarded respiration, pallor of the lips and cheeks, ghastly death-like appearance, and awakening after a long interval as from a pleasant sleep; but Shakespeare would hardly have described the friar as giving sufficient opium to produce forty-two hours' sleep, and being able to predict to an hour the cessation of the action if he had been fully conversant with the properties of opium, unless it may be that stern diseases require stern remedies."

The authors of this paper seem to take the situation too seriously and do not make due allowance for poetical license. A medical writer [38] is of the opinion that Shakespeare is indebted for "his amazing knowledge of medicine" to his son-in-law, Dr. Hall, and finds proof of this assertion in the fact "that most of Shakespeare's knowledge of things medical is displayed in his tragedies, most of which were written in the later years of his life," *i. e.*, after the marriage of his eldest daughter Susanna to Dr. Hall.

As a matter of literary history, almost every calling has claimed Shakespeare. So far as the writer is aware, the apothecaries constitute an exception to this rule. Yet, it must be apparent that Shakespeare could not have belonged to each and every calling that has claimed him for his "amazing" knowledge of its craft. It should prove quite futile, therefore, to assume that the author of "Romeo and Juliet," even if the play he attributed to the more learned Bacon, should know all about the preparation of opium from the juice of the poppy capsule, the reduction of the sticky mass to a powder, and the physiological action of the powdered drug when administered with wine or water as a draught. An approximation of the truth is dramatically as effective, or even more so, than the exact scientific facts could be.

The poison with which Romeo commits suicide. In the oldest Italian version referred to in the historical introduction, Mariotto (the Romeo of the later versions) does not commit suicide at the grave of his beloved one, but, being discovered there, is condemned and beheaded. In Luigi da Porta's "Giulietta," the actors have become members of the nobility of Verona. Hence the fate of Mariotto would not be suitable. Romeo, therefore, as he returns to Verona takes with him a phial of snake poison with which he commits suicide at the

[38] Dr. John Hall: Shakespeare's Son-in-Law. *Johns Hopkins Hospital Bulletin*, 29 (1928), p. 148.

grave of his supposedly dead wife. In the third story we learn something more about the "phial that was filled with a very poisonous juice." Romeo later refers to it as the "snake poison . . . which . . . requires scarcely an hour in which to kill"; also as the "phial which that Spolentine in Mantua gave you who exhibited the living vipers and snakes." Finally, realizing that death is approaching, he once more refers to the poison "of the deadly water which courses devouringly through all my veins."

None of these Italian stories have need of the apothecary. In the first story the great lover is apprehended and beheaded. When he becomes a member of the nobility, as in the later stories, he carries with him his phial of poison much as he does his sword. It is not until we come to the French version of Boisteau that the apothecary is introduced as the source of Romeo's poison. Being informed of Juliet's supposed death, he recalls the shop of an apothecary, which was but poorly equipped with bottles and other pharmaceutical paraphernalia, and whose owner, because of his dire poverty, might accede to his wishes. So he takes him aside, saying:

"Master, here are fifty ducats. They are yours if you will give me a strong poison which will kill in a quarter of an hour him who takes it."

"The poor devil—overcome by avarice—agrees to accede to his wishes. Acting before the people (in his shop) as though he were compounding a conventional remedy, he prepared the poison, and whispered to him:

"Monseigneur, I am giving you more than you require. Half of this suffices to kill within an hour the strongest man in the world."

Shakespeare's rendering of the scene in the apothecary shop has been quoted so often that it seems useless to quote it here. Yet to omit it would be like playing "Hamlet" without the Prince of Denmark.

"I do remember an apothecary,—
And hereabout he dwells,—whom late I noted
In tattered weeds, with overwhelming brows,
Culling of simples; meagre were his looks,
Sharp misery had worn him to the bones;
And in his needy shop a tortoise hung,
An alligator stuffed, and other skins
Of ill-shaped fishes; and about his shelves
A beggarly account of empty boxes,
Green, earthen pots, bladders, and musty seeds,
Remnants of packthread, and old cakes of roses,
Were thinly scattered to make up a show,
Noting this penury, to myself I said—
And if a man did need a poison now,
Whose sale is present death in Mantua,
Here lives a caitiff wretch would sell it him."

According to the French version, other customers were present in the apothecary's shop as Romeo enters. According to Shakespeare, the apothecary must be somewhere in the dwelling to the rear of the shop, for Romeo calls out, "What, ho! apothecary," and the latter responds, "Who calls so loud?" Then follow the well-known dialogue and the illegal transaction:

Rom. Come hither, man.—I see that thou art poor;
Hold, there is forty ducats; let me have
A dram of poison; such soon-speeding geer
As will disperse itself through all the veins,
That the life-weary taker may fall dead;
And that the trunk may be discharged of breath
As violently, as hasty powder fired
Doth hurry from the fatal cannon's womb.
Ap. Such mortal drugs I have: but Mantua's law
Is death to any he that utters them.
Rom. Art thou so bare, and full of wretchedness,
And fear'st to die? Famine is in thy cheeks;
Need and oppression stareth in thy eyes;
Upon thy back hangs ragged misery;
The world is not thy friend, nor the world's law.
The world affords no law to make thee rich;
Then be not poor, but break it, and take this.
Ap. My poverty, but not my will, consents.
Rom. I pay thy poverty, and not thy will.
Ap. Put this in any liquid thing you will,
And drink it off; and if you had the strength
Of twenty men, it would despatch you straight.
Rom. There is thy gold, worse poison to men's souls,
Doing more murders in this loathsome world,
Than these poor compounds that thou mayst not sell.
I sell thee poison, thou hast sold me none.
Farewell: buy food, and get thyself in flesh.
Come, cordial; and not poison; go with me
To Juliet's grave, for there I must use thee.

The fate of the Apothecary. Last, and by no means least, in pharmaceutical interest is the fate of the apothecary. The early Italian versions, as we have seen, have no apothecary. The snake charmer from whom Romeo, in Bandello's story, obtains the "deadly water" no doubt had long been beyond reach of the law at the time of the tragedy.

Boisteau introduces the apothecary as the source of the poison with which Romeo commits suicide. As a sort of moral, he not only brings the two families together but he informs us of the fate of the several culprits in the plot. Father Laurens abjures all secret science which interested him in his younger years. Moreover, he acted from sympathy and is pardoned. Pierre, Romeo's servant, is allowed to go scot free. As to the apothecary, however, Romeo, having advised his father of his intentions by letter, also goes out of his way to state

where he had secured the poison with which to commit suicide. Hence the apothecary is apprehended, tortured and hanged.

From the Prince of Verona's investigation and judgment in the final scene of Shakespeare's play we not only learn that Romeo had acted so contemptuously as to write to his father where he had secured the poison, but also of the judge's intention that

"Some shall be pardoned, and some punished."

The drama naturally differs from the story in its make-up. The latter, in summarizing the situation, may relate the fate of the apothecary. In the drama, the act of dragging the apothecary upon the stage to have him hanged would constitute a sort of anticlimax to the tragedy of the two lovers. Moreover, Shakespeare may have felt that emphasis of the "dirty trick" played upon the apothecary by Romeo might have detracted from the sympathy of the audience for the lover if not for that extended to his sweetheart. Hence he merely hints at the fate of the apothecary and lets the audience know that he is to receive his deserved punishment without interfering with the general climax of the play.

* * * * * *

In a study of Shakespeare's apothecary, other matters than the literary conception of the apothecary may well interest the student of the apothecary in literature. Foremost among these may be mentioned the comments on the apothecary by editors of "Romeo and Juliet." Of these again, it ought to be of particular interest to learn something of the attitude of editors of college texts, *i. e.* of teachers who must necessarily exert considerable influence in moulding the minds of young men and women and thus help shape their future attitude toward the calling. However, a study of high school and college texts may well be made the subject of a separate report.

In this connection mention should also be made of Charles and Mary Lamb's "Tales of Shakespeare," since their version is intended for the real young and thus would tend to mould the mind of the future high school and college student.

And as mischief is swift to enter into the thoughts of desperate men, he called to mind a poor apothecary, whose shop in Mantua he had lately passed, and from the beggarly appearance of the man who seemed famished, and the wretched show in his shop of empty boxes ranged on dirty shelves, and other tokens of extreme wretchedness, he had said at the time (perhaps having some misgivings that his own disastrous life might haply meet with a conclusion so desperate). "If a man were to need poison, which by the law of Mantua it is

death to sell, here lives a poor wretch who would sell it to him." These words of his now came into his mind, and he sought out the apothecary, who, after some pretended scruples, Romeo offering him gold which his poverty could not resist, sold him a poison, which if he swallowed, he told him, if he had the strength of twenty men, would quickly despatch him.

Another phase of the study that may well interest the student of the apothecary in literature is the fate which the apothecary meets at the hands of the performer on the stage. Though the apothecary may afford less occasion for real acting than the nurse in one of the earlier acts, yet the opportunity for scenic effect is by far greater.

A relatively recent account of a French rendering is given by the Paris correspondent of the *London Chemist and Druggist:*[39]

No dramatist, one may believe, has ever been bold enough to produce a version of "Romeo and Juliet" without the apothecary, so I was glad to see the play in French at the Odeon Theatre, Paris, where M. Antoine has staged the Shakespearian idyll so successfully that I found it necessary to book a week in advance. But my hopes of seeing a new edition of the classic pharmacy were disappointed—the apothecary appears to emerge from some subterranean retreat. Scientists inform us that underground plants lose their colour and become white and transparent, and this description exactly applies to the Odeon spectre. His "make-up" (like the nurse's) shows an exaggeration which mars an otherwise interesting and well-acted version of the great dramatic play.

This phase of Shakespeare's drama may also be made the subject of special study and report.

This preliminary study of the apothecary, as drawn by Shakespeare, would be incomplete without reference to the artist's conception thereof. If Shakespeare's description of this character has proven one of the most popular for after-dinner speeches at pharmaceutical banquets, his delineation by artists has proven about equally popular with the illustrator of Shakespeare and of pharmaceutical commencement programs. A collection of these, quite aside of any artistic merit which some of them possess, should prove valuable as throwing light from another angle on Shakespeare's "caitiff wretch."

In closing this attempt at a somewhat more comprehensive study of Shakespeare's famous apothecary, it may not be out of place to allude to a criticism "on the medical profession and the competitive system" by one of England's greatest living playwrights. Reference is had to Bernard Shaw's remarks made at a meeting of the Medico-Legal Society in London in 1909 and published in the *Lancet.*[40]

[39] Jan. 14, 1911, p. 37.

[40] An abridged account may be found in the *Jour. A. M. A.* for April 17, 1909, p. 1282.

The attitude of socialism toward the poor man was always that the poor man was necessarily a bad and dangerous man. The attitude of the man who was not a socialist toward poverty was that poverty was a very good thing, that it developed character, and in other particulars had a beneficial effect. But the really sensible man always regarded poverty as a bad thing and held that the poor man was always dangerous, and that the doctor was a specially dangerous man when poor. The doctor's poverty at the present time drove him necessarily into doing things which he would not do if he were independent. He was—like most men—as honest as he could afford to be.

This is as true of the apothecary as of the physician. It was for this very reason that concessions, originally, no doubt, granted by city senates to attract competent apothecaries as necessary for the general social welfare of its burgers, were continued as a means of protecting its citizens in order to avoid dishonest competition among the ranks of the apothecaries. In a sense, such an arrangement is undemocratic; in another it is of the very essence of democracy, for it is intended not as a means to enrich the apothecary but as a protection of the demos the people.

SILICON

THE ELEMENT OF A THOUSAND USES*

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INTRODUCTION

1. Scope

THE GIGANTIC struggle of man to understand the laws of nature and to harness its forces may be witnessed through the ages. Considering the growing use for just one, the most abundant element on earth—"silicon"—we may follow with fascination the human progress to the very frontier of the present battleground of industrial life. One of the first magic forces conquered in a magic way, probably, was fire, and with it heat, produced through friction and the combination of wood carbon and oxygen of the air. Thus the cave man of the stone age learned to warm his crude home, to boil or fry his food.

Arno Viehoever, Ph. D.

This early age is marked through the discovery and use of the firestone—flint. Man soon, as we must conclude from early records, applied the resistant properties of the stone to tools, weapons, and as an aid in the making of fire. The skill displayed in the cutting, pointing, shaping of these stones for his needs is a vivid token of human resourcefulness.

The fuller use of heat led to the making of chinaware, enamel, glass, and finally fused quartz and alloys; the skill of molding to the making of pottery, that of cutting and polishing to the beautification of stones and natural minerals—the creation of jewels, the understanding of the varying hardness of materials to the use of abrasives; the utilization of the hydrating and adhesive properties to the production of building materials—cements, binders, and glues; the discovery of the nonconducting properties of certain silicate compounds to the development of effective insulators against heat, temperature, fire, sound and electricity; the porosity of natural and especially of certain new artificial combinations, to the preparation of filters, absorbing and

*Popular Science Talks, 1931 Season.

adsorbing media found of such magic help in new as well as old industries, the curative properties of certain, and the larvicidal properties of other silicates led to their use in medicine and as insecticides.

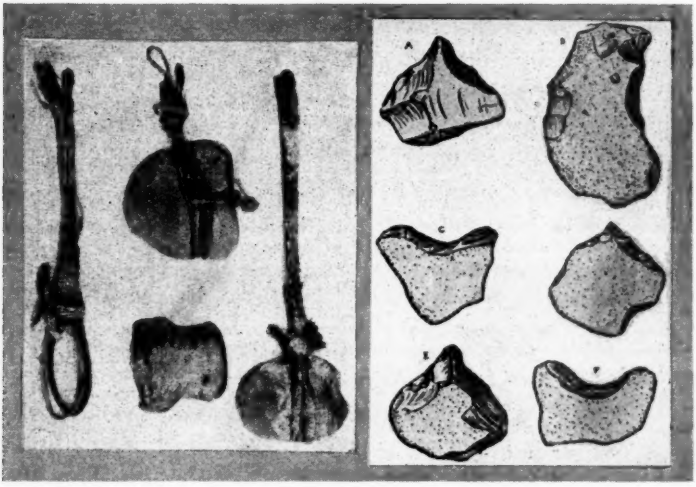


Fig. 1.

a. Flint Stones, shaped by human hands over one million years ago, found in England.
b. Stone Hammers with wooden handles, found in the prehistoric salt mines near St. Thomas, Nevada. (After Umschau.)

Were we to name all possibilities within our reach to employ just this one element and its many compounds—in industry or home—we would be adding, count for count, to reach, no doubt, a thousand uses.

In the primitive period man made essential use of natural supplies without much changing their nature. In the adaptive period he modified these raw materials to suit his needs; thus he made bricks, pottery, tiles from clay; glass from sand, soda or plant ash, at least several thousand years before Christ's birth. In the creative period man finally produced materials greatly different from the natural raw supplies. Thus from primitive surroundings man has reached out and put the natural forces to work, has opened new channels for civilization and changed the course of his destiny.

2. Natural Products

Mineral Sources—Silica

GENERAL DATA

Silicon has been found in the heavens, in the sun and in many stars by means of its specific lines recognized in spectral analysis. On earth it does not occur in its elemental state,

though about one hundred years ago—1823, to be exact—Berzelius isolated it from its natural compounds.

The most abundant source of silicon is sand or the impure combination of silicon with oxygen, covering such large areas of our globe and forming also an important constituent of many minerals. This oxygen compound $Si O_2$, "Silica," occurring both free and combined with metallic oxides as silicates, constitutes about 60 per cent. of the solid earth crust. In the free state it forms the greater part of sand and sandy rocks. It occurs in a variety of forms, crystalline, submicroscopic, or cryptocrystalline, and in finely divided and hydrated amorphous modifications. Sosman describes the crystalline forms as follows:

The 8 Well-known Modifications of Silica

Low-Quartz	Stable at atmospheric temperature and up to 573° C.
High-Quartz	Stable from 573° to 870° C.; existing above 870° as unstable form.
Low-Tridymite	Capable of existing at atmospheric temperature and up to 117° C. as unstable form.
Lower High Tridymite..	Capable of existing between 117° and 163° C. as unstable form.
Upper High Tridymite..	Capable of existing above 163° C., stable from 870° to 1470°, above as unstable form, melts at 1670° C.
Low-Cristobalite	Capable of existing at atmospheric temperatures and up to 200°-275° C., as unstable form.
High-Cristobalite.....	Capable of existing at 200°-275°, stable from above 1470°-1710° C. (1710° melting point).
Vitreous Silica or Silica Glass	Capable of existing at atmospheric temperatures up to 1000° C. and above. Begins to crystallize with measurable rapidity above 1000° C. Is an unstable, undercooled liquid (a glass) at temperatures below 1710° C.

Less well known are the submicroscopic or cryptocrystalline forms represented by chalcedonic silica, the finely divided amorphous varieties as precipitated silica, and the hydrated amorphous forms as

opal, belonging with the system Silica ($Si O_2 : H_2O$) Water. Various quartz gems and semi-precious stones, discussed under the caption "Silicon Jewels," are representatives of certain of these modifications.

The silicates, forming the chief constituents of various rocks, soils, clays, are combinations of silica with aluminum, magnesium, iron, alkali and alkaline earth elements. Aside from the mineral distribution of silica we find that probably all plants and animals contain some (however small the amount may be) silica or silicates as a needed constituent for certain functions. Some plants, as we shall see later, deposit fairly large amounts in their tissues. Outstanding are the skeleton deposits from microscopic aquatic plants, fresh and salt-water diatoms, mined as diatomaceous earth.

COMMERCIAL SILICA

When rocks like granite disintegrate, we may find (as we have mentioned in a previous lecture on "Soil and Sod") such component parts as sand, silica, or quartz, mica and feldspar. After further weathering of feldspar and other rocks, yielding, as we shall see, various kinds of clay or mud, which may be washed away, we find again that sand will remain, the sand of the desert, the dunes, the sea.

QUARTZ

Quartz, a miner's word, coming down from the Middle Ages in Germany, is commercially applied to the crystalline and vitreous variety of silica. It is produced from vein quartz, occurring only occasionally transparent (see Silicon Jewels), but mostly white opaque to translucent, due usually to a fine inclusion of gas, liquids or other impurities. The clear, transparent "rock crystals" are mainly used in fused ware, as we have described elsewhere. No deposits of commercially useful crystals have evidently been discovered thus far in the United States. Quartz ground in different degrees of fineness finds its use in soaps, cleansing powders, pottery, enamelware, porcelain industries for glazing purposes, glass paper for abrasive purposes, and in fused glassware. Comparatively large pieces of quartz are used, although only in small amounts, as packing in acid towers, as a flux in smelting. Jointly with feldspar, quartz is sometimes quarried for flooring, wall tile and pottery works.

QUARTZITE

A rock, looking like massive quartz as the intergranular spaces are filled with quartz. It is the important raw material for the silica refractories, for the silica abrasives used in metallurgical and chemical processes. It is specifically quarried for use in nickel-copper smelters, for ferro-silicon (duriron) plants,

manufacture of silica bricks, used in the iron industry, and for refractory bricks used for lining of blast furnaces. Quartz crystals are used in radio sending stations to keep the wave length constant. It has most recently been recommended for accurate clocks and chronometers. The crystals oscillate between two metal plates when indirect current passes through and retain the same number of oscillations if air pressure and atmosphere remain constant. Quartz, cut in disks or tubes, exhibits essentially the properties described for fused apparatus.

SANDSTONE Grains of sand are cemented together by silica, iron oxide or calcium carbonate. The silica content, the nature and efficiency of the cement, the size of the sand grains, determine the value of sandstone. It is considered a most useful and durable building stone and is then judged for color and resistance to wear as well. Pulpstones, whetstones, grindstones, are additional uses; they may furnish sand for glass, filter and blast sand.

SAND A fine granular material, produced by nature and mainly composed of silica. The largest amounts are used in construction work, bricks, concrete, road building and plaster sand. Size and purity are essential, as they insure a satisfactory finished product. Molding sand for steel casting, for cast-iron, for nonferrous metals, should be high in silica. Good glass sand should contain over 99 per cent. silica. Engine sand, abrasive sand for plate glass, grinding and sandblasting filter sand are judged by purity and size; furnace sand by high silica content to be refractory. Potters placing sand, roofing and flooring sand and other special sands must meet specific requirements to serve satisfactorily in definite needs. The attempts to replace sand in sandpaper with garnet have evidently not been very successful as the garnet crystals in many cases will not stand the necessary physical tests required.

TRIPOLI (SOFT SILICA) The name "Tripoli" was first applied to diatomaceous earth imported from Tripoli (Northern Africa) and then in 1871 applied to a seemingly similar product mined near Seneca, Mo. This product proved to be chalcedony quartz, a white, creamy or rose (depending upon metallic impurities), finely granulated porous silicious rock, fibrous in character. The Seneca deposit, or the stone from the quarries, contains 20 to 35 per cent. moisture, according to season and rainfall. Dried first in drying sheds, then in artificial heat driers, the material is ground in pebble mills and separated by screens and air flotation in various grades. The

Husband Brothers first developed this mine; they organized the Monarch Tripoli Company in 1871, selling the stone sawed in brick shapes as "American bath bricks" for scouring and polishing. Since 1885, when a grinding mill was installed, the powder has been sold in increasing amounts as a mild abrasive in scouring and polishing, in polishing compositions, liquids and pastes. It first cuts; breaking down under pressure, it polishes with a minimum of harshness; thus claim the distributors. It is used in soap, soap powders, scouring powders and cakes.

In 1905 an old customer of tripoli learned to waterproof it; thus a new market was found for the product, called "foundry parting," for that purpose replacing the more expensive lycopodium then in use. Adding to polishing preparations, containing stearic acid, tallow, paraffin, petrolatum, etc., this tripoli powder, it is effectively held in combination due to its porosity and its absorption power.

The marketing of filterstones, long an outlet for the product, had to be discontinued in 1915, as the improvement of communal water systems had made their use unnecessary. As a filler in hard rubber, substitute compositions, phonograph records, etc., it had to compete with other, often cheaper, products; in consequence this outlet is not an important one.

In 1926 it was found that Seneca tripoli gives an increased workability, flowability, density, water-tightness, strength and durability to concrete, due to its colloidal and other characteristics. Whether this use in concrete has been suggested by similar claims made for diatomaceous earth when used in concrete we do not know; but we can learn much from the study of a struggle now going on for sixty years to adequately utilize a natural product. As new properties were discovered new outlets were usually found so that the production of that same mine, now selling only "Barnsdall Tripoli," was 16,264 tons in 1929. There are other deposits in Illinois and Tennessee which are used to some extent as a source of silica in the manufacture of whiteware. The price for this and other uses is usually greater than for good silica sand.

AGATE

The material, not used for ornamental purpose and for semi-precious stones, must be uniform and free from defects. It serves for knife edges in analytical balances, as bearings in scientific instruments, as balls for water meters, as mortars and pestles, as burnishers and writing styles, as umbrella handles, paper knives, jewel boxes.

FLINT It is dull-colored, hydrated silica, holding loosely varying amounts of water. Used in the Stone Age for flint implements, by the Indians even unto recent times as arrowheads; universally, before the invention of the match, as a fire producer (flintlock, tinderbox and steel); as natural flint pebbles in grinding without contamination; in flint linings; as potters' flint, though this is being replaced by the cheaper high-grade silica sand.

3. Silicon Jewels

Rarity of the jewel, hardness—that is, resistance to wear—of the gem, transparency of the stone and the color or the play of colors determine, according to jewel experts, the beauty and value of the jewel. Various varieties of quartz and other silicon compounds have been used in ancient times and are still valued as jewels for the qualities above stated. In fact, these jewels were so highly valued that the Egyptians made glass imitations as early as 5000-6000 B. C. at least. In the oldest tombs excavated glass imitations were found of rubies, emeralds, sapphires, of other precious stones and beads. These glass beads evidently were sold by the traders to barbarians as rare jewels; the beads showed remarkable variety in design, color, and some were beautiful indeed. Some jewels, and especially opals, are the carriers, as fear and rumors have suspected through the ages, of bad luck and tragedy.

CRYSTALLINE QUARTZ JEWELS Occurring in well-formed crystals, the colorless "rock crystal" is little used in jewels, unless they may be so polished or painted as to bring out the reflections of colors or some of the brilliancy of the diamond. Rock crystals are used in ornaments and in optometry. Important sources are the Alps, Brazil, and Madagascar.

The colored, apparently homogeneous varieties include a number of well-known stones:

Amethyst, a clear purple or purplish violet stone, in varying shades of color depth. It was worn in ancient times against drunkenness, as a preventive against violent passions, and is now used in seal rings and other jewelry. The main sources are reported to be South Brazil and the Ural Mountains.

Citrin, or False Topaz, a light yellow to brown-yellow stone used in jewelry like the amethyst. It may be found in nature or obtained through suitable heating of amethyst or smoky quartz. Thus the

Spanish or Madeira topaz stones are obtained as the finest citrin gems through heating of Spanish smoky topaz.

SMOKY QUARTZ OR SMOKY TOPAZ Light to dark brown, almost black (then known as moriom); if transparent, a very pretty stone, then used like rock crystal, as it is the only wholly brown clear jewel stone occurring in quantity and in larger pieces. The Scottish topaz stones or cairngorms are dark, smoky brown crystals found in the region of the mountain Cairngorm.

Rose quartz, rose red or pink, used in bead chains, is found in Brazil, North America, and Germany.

Cat's-eye, tiger-eye, and falcon eye are names for gem stones representing quartz varieties, with certain inclusions, which make them appear as animal eyes and suitable for ornaments especially after polishing. Cat's-eye is the gem that warns against danger and trouble.

Prasem represents natural microfibrous silica; the color is leek green. The stone, found in Saxony, is worn as a ring stone, a practice which even the old Romans followed.

Chrysopras, also a microfibrous silica stone, contains nickel, thus producing a green stone much used in ornaments. It occurs in Germany and was already highly valued by King Frederick the Great. It also occurs in East India and California and is imitated by chalcedony after this is colored green artificially.

OPAL It is one of the "Big Six" precious stones (emerald, fancy diamond, ruby, sapphire, pearl, opal) classified as quartz; however, it is never crystallized; being amorphous it contains as a gel a tiny amount of water. It is hard to mount, being rather soft, but is highly valued for its play of colors with brilliant green, yellow and red flashes, the finest stones selling as high as $300 a carat (.2 gms.). Nevertheless, in the language of gems opal is considered an "unlucky" stone, foreboding injury and mental or physical trouble.

CHALCEDONY This stone is a mixture of quartz and opal, the proportion of opal present evidently accounting for all characters of chalcedony. While it is usually white, gray, yellow-brown and otherwise colored, stones of waxy lustre may occur in natural deposits. In all known ages of the past chalcedony has been used by engravers of gems. Many of the colored varieties are still prepared for use as ornamentals or gems, and are known as agate onyx, a bloodstone or heliotrope (with red spots on dark green polished back-

ground), carnelian, chrysopras, mocha stone, etc. Chalcedony is considered the gem that dispels sadness.

AGATE A jewel stone, consisting of amorphous and crystalline silica, has long been known. Theophrastus asserted that the origin of the name was derived from a Sicilian river then called "Achates," where the stone was first found. Most agates have been found in eruptive rocks or lavas, replacing the cavities formed after escape of gases occurring during the cooling of the molten rock. They have distinct bands, their shape and color determine the variety. Agate is the symbol of health, long life and prosperity.

ONYX It represents an agate with cloudy bands, which alternate with bands of another color, thus forming a striped agate with layers sharply marked off from and alternating with white. Onyx has been frequently used in cameo work, the design and background permitting suitable cutting in different colored layers, inferior stones or glass imitations are widely used for cameos, but onxy is still much used for small ornaments as beads, brooches, rings, or large stones for cups and vases. South America and India are considered the main sources, while Mexican and Algerian onxy, Gibraltar stone and onyx marble are considered less precious and, as softer, less suitable. Onyx is said to insure married happiness.

AGATE JASPER AND JASPER The first one has properties placing it between true jasper and chalcedony. Jasper is classified as an impure variety of quartz, occurring in varied colors from dark green, brown and yellow to blue or black. While the Jaspis jewel of old was rather transparent, containing probably chalcedony and chrysopras, the name jasper refers now mainly to opaque stones. Ancient people believed in the medicinal value of jasper and as late as 1609 published reference is made of the belief that the stone, if hung around the neck, would strengthen the stomach. It is also considered as the stone of wisdom and courage. Brown Egyptian jasper has been found in the Nile Valley; red jasper in Dakota or in Hessia, Germany. In Siberian stones as well as in Riband jasper the colors are arranged in bands with red and green stripes. Artificially colored jasper is sold as imitation lapis lazuli.

LAPIS LAZULI The true stone, with gold-like specks of pyrite like the stars in the deep blue heavens, has since ancient times been used for small ornaments and other decorative purposes.

It is principally luzulite, a sodium-aluminum-sulphur compound with aluminum silicate, found in crystalline limestone near granite masses, mined principally in Afghanistan, where the famous traveler Marco Polo in 1271 found it.

GARNET The name refers to a closely related group of silicate minerals—aluminum, iron, chromium, garnet—and is derived from the red fruit pomegranate. It occurs widely, chiefly in schist formation. Garnet beads were worn in ancient Egypt and garnet was much used for engraved gems in the Roman empire. The alamandine (iron-aluminum garnet of deep red to purple color), the pyrope-magnesium-aluminum garnet deep red to blood red color or the brown "cape ruby," and the grass-green demantoid (calcium chromium of calcium ferric garnet) are among the gem stones valued today for color and luster or dispersion power.

JADE Spanish conquerors of Mexico and Peru (1565) perpetuated the name and the belief of the curative properties of this "colic" stone in kidney and other intestinal diseases, in strengthening of the body, prevention of fatigue, prolonging of life, and prevention of decomposition, if taken in sufficient amounts just before death. The colors vary from nearly white and dark green. In prehistoric times even jade has been used in the manufacture of ornament weapons, utensils. The Chinese sawed the mineral into the desired shape with steel wire strung on a bamboo bow. The name Jade is usually restricted to the minerals jadeite (silicate of aluminum and sodium with some iron, calcium, and magnesium), and nephrite (calcium and magnesium silicate with a little iron). The Chinese value jade more than all other precious stones, the name signifying also five cardinal virtues: charity, modesty, courage, justice and wisdom.

4. Commercial Silicates

According to recent studies the outermost layer of the earth crust contains predominantly the lighter metal silicates as aluminum silicate —granite; the heavier, as magnesium silicate—basalt—are found below. Oxygen, sulphur compounds and metals are believed to lie beneath these layers in the thirty-mile thick earth crust. The chief constituents of the coarse granite or mineral pegmatite are silica and the silicate feldspar, occurring in dikes worked as open pits or quarries.

Analyses of Spars

	High-grade Feld Spar	Potash Spar
Silica	72.70%	64.88%
Aluminum	15.29%	18.36%
Ferric oxide	.37%	.24%
Lime	.26%	..
Magnesia	..	trace
Soda	3.00%	2.02%
Potash	8.56%	14.09%
Water	..	.31%
Suited for:	Glass, Pottery, Whiteware, Allied Industries	Finest Pottery Ware Electrical Trade

Ground feldspar is used in the manufacture of floor and wall tiles, pottery, stoneware, enamel and porcelain ware.

CLAY

Since the earliest time of human history we find clay used by man. Indeed the molding of clay is considered the oldest handicraft in the world. It is abundantly found in nature as it is formed by weathering of rocks as feldspar and mica:

$$\underset{\text{Feldspar}}{Al_2O_2K_2O.6SiO_2} + \underset{\text{Carbon-dioxide}}{6CO_2} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\text{Clay}}{Al_2O_3.2SiO_2.2H_2O} + \underset{\text{Potash}}{K_2CO_3} + \underset{\text{Silica}}{4SiO_2}$$

Clays consist mostly of silicate of aluminum and form then the white kaolin or china clay; they also contain often calcium, iron and sometimes manganese. Marl is a clay containing chalk or calcium carbonate. The residual clays are the deposits found over or near the clay-forming rocks; they are mostly lighter for and after backing than the sedimentary clays, which have been carried away from the rocks forming them and have been deposited elsewhere. When wet, most clays possess plasticity and become hard and stonelike on baking, retaining the shape of the molded article. Thus we find clays used for pottery and other molded articles, as well as buildings and building blocks since the most ancient times.

	Glacial Clays	Shales—Surface Glacial Clays	China—Ball Clays	Fire Clay
Yield:	White Buff Bricks Red	Heavy Clay products Bricks; Sewer pipes Drain and structural tiles	Whiteware High- and low-tension porcelain	Pottery Stoneware

While the potter shapes the clay and then bakes it, Professor Shaw, from Penn State College, adapted the principle of processing steel to clay. He fires and vitrifies the clay, then shapes it under pressure, rolls it into the desired form, presses it into the mold and anneals it at lower temperature, thus permitting the development of a strong, dense, crystalline structure. Eight by twenty feet is the largest slab that can be made now for paving—"from a useless earth (cyanite, sky-blue aluminum silicate, abundant in the Alleghanies), more durable than concrete and cheaper than macadam."

FULLER'S EARTH (Hydrous Aluminum Silicate) Whether a certain clay is fuller's earth is no simple matter to determine, says Dr. Parsons. Its bleaching power is practically the only characteristic by which it can be identified. The adsorptive value should be evident, the specimens used by the pharmacist should show high adsorptive activity. Lloyd's reagent is a fuller's earth able to adsorb one-eighth its weight of quinine bisulphate. Lloyd described the discovery of his reagent for alkaloidal adsorption in his inimical way: "I made a mixture of berberine sulphate (bright yellow) and fuller's earth (1:20), added the same to distilled water, agitated the mixture well, and filtered. Behold! the filtrate passed colorless and devoid of alkaloid. I placed some of the residue upon the filter paper, on my tongue. It was tasteless. This mixture likewise, when digested with diluted acid and filtered, gave no evidence of an alkaloid being present."

SLATE Certain types of clay, under high natural pressure, yielded a sedimentary rock called slate and originally almost entirely used for slate roof, then blackboards and school slates.

Newer Uses of Slate and Slate Flour

Mantles, window sills, wainscoting, floor tiles, lavatory slabs, vats, sinks, steps, billiard and table tops, hearths, risers, electric switchboard, well caps, flour bins, refrigerator shelves, dough troughs, base boards, grave vaults, ornamental floors, ornamental walks; painted, baked, marbleized finish; slate for novelties, as clocks, inkwells, paperweights; filler in paints, roofing mastic, road asphalt surface mixtures in other products.

TALCUM It is essentially a hydrated silicate of magnesia occurring crystalline or in compact masses. It is a soft mineral, creamy white, gray or apple green, with a pearly luster and a greasy touch. Mineral talc is best known in the finely ground form

"talcum powder," obtained through crushing, drying, and bolting of the product through silk cloth. In a bulletin of the Ontario Department of Mines we find the uses of talcum enumerated as follows:

Uses of Talc

In paper manufacture: Fineness 200 mesh, free from grit; as part of the glazing and surfacing mixture; as a filler or loader to give body.

Roofing felt: 150 mesh for filling and coating; as a filler or loader to give body; 40-80 mesh for surfacing; to increase weather resistance in coat and prevent sticking.

Textiles: 200 mesh and pure white; as a filler.

Rubber manufacture: To prevent sticking of surfaces during handling and vulcanizing; for dusting molds or to bury white goods in while vulcanizing; as a filler.

Paints: 200 mesh; talc does not settle as readily as china clay.

Foundry facings: Replaces or is mixed with graphite.

Toilet preparations: No grit.

Soap: As a filler.

Lubricants: Having a low coefficient of friction.

Linoleum and oilcloth: As a filler and for dusting.

Pottery: Renders it tough and resistant to sudden changes in temperature.

Leather: For dressing hides and fine leather.

The outstanding properties of talc are softness and slipperiness, desired in toilet preparations; refractoriness, nonconductivity of heat and electricity, resistance to the action of most chemicals.

SOAPSTONE

This is an impure talc with a soapy feeling, consisting essentially of silicates of magnesium, iron and aluminum, in varying proportions. Its mechanical structure, properties, and chemical composition determine the value. The massive pieces are used as slabs, bricks, blocks; as they do not split, scale or fuse even at fairly high temperatures they are used in increasing amounts; even in chemical laboratories, where the slabs cover the desks. Additional uses are enumerated in the bulletin of the Ontario Department of Mines as follows:

Uses of Soapstone

Metallurgical: As molds for casting copper, brass, etc.

Lining for furnace in sulphate paper mills: Charge will not stick.

Electric switchboards, base plates, laboratory tables: It can be sawn, drilled, or worked in a lathe.

Bricks for fireless cookers, footwarmers, heating elements for furnaces and bakeovens: It has great powers to absorb and retain heat.

Refrigeration: For insulation.

Marking iron and steel: Sawn into crayons and pencils.

Tailor's, or French chalk: For marking.

Carvings: Used by Oriental nations.

BENTONITE This material came to the attention of western oil firms in a very peculiar way. A caller offered them a filtering medium other than bleaching or fuller's earth, stating, "Give me what you save using this new stuff and we both make a profit." The experiments were successful, as filtration was quicker, the oil completely discolored, the losses of valuable substances reduced. Bentonite is another form of hydrous aluminum silicate, first found near Fort Benton, Wyoming, now also found in Tennessee, Kentucky, Alabama, Mexico, France, China. It is probably formed through chemical change of vitreous volcanic ash. It absorbs large amounts of water, swells, forming a soap-like and finally a jelly-like mass. Indians, prospectors, pioneers in the regions around Hudson Bay knew its cleansing properties, some referring to it as mineral soap, using it for washing their woolen blankets. The cleansing property, increased in the presence of alkali, permits the removal of oil, grease from hands, cloths and glass without soap, although this still further improves its value.

Bentonite—

Increases the property of emulsification; useful in insecticides, fungicides, paint.

Increases cleaning properties of soap, due to its colloidal, adsorptive properties.

Increases softness of toilet soap.

Serves as a clearing agent; useful in oil and sugar refineries.

Serves as a foundry product added to sand; the same sand form may be used oftener.

Serves as a colloidal, absorptive agent; useful in cosmetics, powder ointments.

Serves as a filler and plasticiser, in paper, linoleum, ropes, rubber, cement, pottery, lubricating oils, glass cement, phonograph records, lead pencils, glue, electrical insulators, in shoe and oven polish.

SILIMANITE

During the great war in 1917 the expeditionary force found that the porcelain insulators used as spark plugs, placed in the fighting planes, were unreliable. An aluminum silicate, "silimanite" ($Al_2O_3SiO_2$) was synthetically produced until a natural deposit was discovered and its properties could be economically utilized in the manufacture of chemical ware in 1928. When used as a ceramic body and fired it is said to have a denser and more homogeneous structure than the porcelain which contains quartz and feldspar, showing quartz crystals. Greater mechanical strength, nonporosity, resistance to sudden and repeated temperature changes, dependent upon chemical and physical strength, save at least, according to the manufacturers, 25 per cent. in breakage as if porcelain were

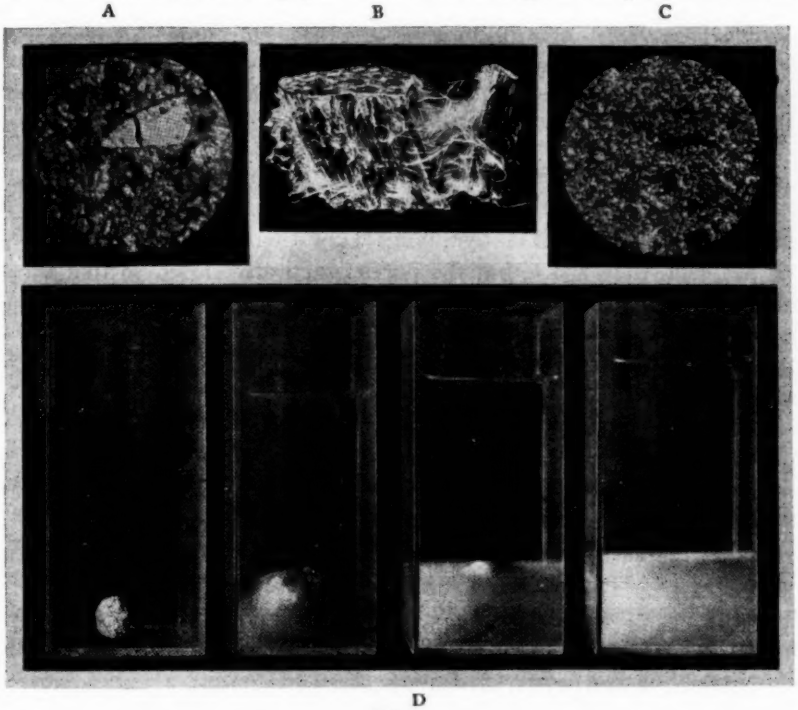


Fig. 2.

a. Chemical ware: Section through crystal of quartz in porcelain cracked by pressure due to an unequal expansion.
b. A piece of crude asbestos, the fibres of which are mixed with Portland cement in form rigid asbestos shingles—or are used alone in many other ways for many other purposes. (After Ambler Asbestos Co.)
c. Chemical ware: Section through sillimanite; note absence of quartz grains and close grained homogeneous structure. (After Central Scientific Co.)
d. Bentonite in glass container covered with water: 1st, dry; 2d, after 3 hours; 3d, after 8 hours; 4th, after 24 hours. (After Umschau.)

used. The thermal conductivity is so much higher than that of chemical porcelain that the time saved in evaporating and cooling it is calculated to be about 15 per cent. in average.

PUMICE (Lava) STONE This is a very porous rock, owing its peculiar froth-like structure to the escape of vapor, upon relief from pressure during the extrusion of vitreous lava at the earth's surface. It varies in chemical composition like the more compact vitreous lavas. It is widely distributed over the earth in small fragments and occurs in all deposits covering the bottom of the seas, both from submarine eruptions as well as from volcanic eruptions on land. It is found in Nevada, but is usually imported from the Lipari Islands when it is to be used for polishing metals, marble, woods, pasteboard, in soap, in powder. It is said to give a good glaze to pottery and is a good packing material for vinegar generators, its porous nature affording large areas for oxidation of the alcoholic liquids to vinegar.

SYNTHOPORIT A new pumice stone-like material, consisting mainly of fused then foamed calcium silicate, patented and made by the German I. G. dye industry, as a light building stone with 80 per cent. pore space, but the pores practically closed so that they absorb little water but insulate against heat. It is said to give rigidity and elasticity to cement, to serve for foundations as well as for roofings, to be used to surround steel girders—everywhere where light weight of the building material is an advantage.

ASBESTOS One of the most important of the insoluble, naturally occurring silicates, is no doubt the mineral which yields the product so well known in the trade as asbestos. It was certainly known to the ancient world. Plutarch refers to the "perpetual lampwick," used by vestal virgins. Shrouds of woven asbestos were evidently used for cremations in ancient times. The funeral dress of kings, called "Linum vivum," is also reported to have been made of asbestos material.

Asbestos consists of the silicates of lime and magnesia with or without iron; the hydrous silicate of magnesia with or without iron is also called serpentine.

The United States of America is considered the largest consumer, requiring three-fourths of the world's output, using mainly the material mined in Canada.

The following uses are recommended by one manufacturer as suggestions in asbestos:

Brake lining	Ring packing	Tube stoppers
Stove lining collars	Metal sheet packing	Boiler plugs
Floor flange	Cloth packing	Gauge glass washers
Gaskets	Sheet packing	Moving picture booths
Mill board	Wick packing	Shingles
Roll board	Braided packing, graphited	Paper
Cinder belt conveyor	Baking sheets	Yarn
Stove lining cement	Corrugated sheeting	Cord
Furnace cement	Pipe covering	Fibre felt
Magnesia cement	Air cell covering	Cloth
Joint runners	Tubing	Gloves
Iron holders	Autobestos for engines	Mats
Sectional blocks		Curtains in theatres

These and other uses are possible, because asbestos is incombustible and has also remarkable insulating properties, making it invaluable in industry for fireproofing and heat protection; it serves as an electrical insulator, provides sound and damp-proofing. The length, fineness and infusibility of the fibre determine the commercial value. The longest fibres are spun with yarn, with cotton, with metal wire; the shorter fibres are mixed with cement and may be molded in special shapes or used in paints, like roof paints.

MICA

It occurs generally in irregular-shaped pockets, in beds, vein-like in nature, following the strike of the gneiss-like intrusive rocks or contacts of these rocks with crystalline, dolomitic limestones. Three countries—India, United States, and Canada—are the principal producing countries. Although mica was mined in the early 70's together with phosphates in Canada, the demand was very small, as it was probably only used for heat insulation as in stove windows or lamp chimneys. With the demand for electrical insulators its use rapidly increased. Especially the softer, more flexible sheets are more suitable for insulating electrical equipment. These mica sheets usually have a size of three to five inches, but at the Lacey mine in Sydenham mica crystals six feet across at the base have been mined. Chemically, mica represents the silicates of aluminum with the alkalies potassium, sodium, lithium, cerium; basic hydrogen; in some types with magnesium, ferrous and ferric iron, etc.

Scrap mica is now in demand, being powdered in varying degrees of fineness and used in the manufacture of wall paper, paints, lubricants, as an adsorbent for disinfectants and explosives, as an insulating cement, in the rubber industry, in asphalt roofing shingles, in stage scenery, in producing a frosted effect on toys, etc.

5. Silicon in Lower Forms of Life

On land and in sea we find ample evidence of silica used in the life of simpler forms mainly for the purpose of skeleton formation. The one-celled representatives as rhizopodes, certain sponges, especially the glass sponges and their spicules or needles are very rich in silica. Analyses showed readily evidence of its presence in their skeletons. The placenta of a certain glass sponge Geodia cydonium showed a water content of 6 per cent. and over 92 per cent. of silica, the remainder consisting of the oxides of magnesium, potassium, sodium and traces of clay and lime. The needles of another glass sponge, Monoraphis chumi, even showed 96 per cent. silica, the remainder consisting of potassium, sodium, iron, fluorine and traces of chlorine.

Equally in simple plants of the algæ type, namely the diatoms, both in the living and especially the fossil shells, we find silica. They may be fresh or salt water forms and occur in vast deposits as diatomaceous earth throughout various parts of the world. It is an interesting fact that the fossil forms are very similar, indeed often identical, with the now living representatives. The largest worked fossil deposit is that of the White Hills at Lompoc, California, covering several square miles, ranging in thickness up to 100 feet. It is apparently horizontally laid down at the bottom of a fresh-water miocene sea, the deposits in that region generally dating back to the tertiary age. The Florida deposit near Clearmont, Fla., yielding "diatomite," is of recent origin and of a different type.

At Lompoc we witness surface mining with scraper and power shovels. Over 2000 species of diatoms have been identified; a few of the disk-like Casseinodiscus species prevail. As the character of the various beds varies, they are selected for special uses. Since this California deposit at White Hills has become the property of big financial and industrial interests (the Johns-Manville Corporation bought it three years ago), the production has greatly increased and new outlets for the use of the material have been created; thus it has been recommended for 137 different purposes in filtration processes as well as in various forms of insulation and for use in buildings as well as in building materials.

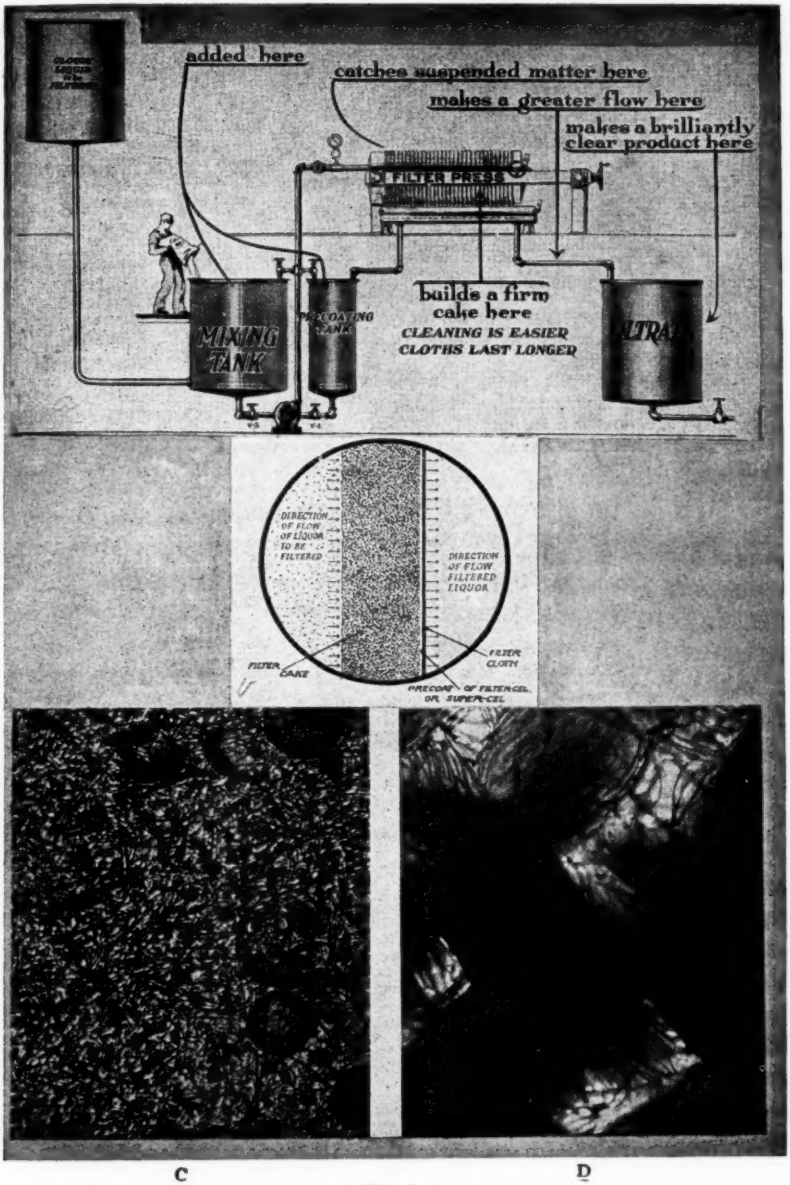


Fig. 3.

a. **Typical filtration system.**
b. **Cross-section through a filter cake.**
c. **Filter-aid, enlarged 200 diameters, forming a matte on filter cloth.**
d. **Filter cloth, closely woven, enlarged 200 diameters, showing "open screen without the matte of the filter-aid (diatome shells)." (After Johns-Manville Corp.)**

Diatomaceous Earth and Its Uses

Snow Flow Super Flow	Very light powdery material, obtained by flotation.	For filler; abrasers, polishing
Hyflo Super Cel	with largest sized pores, permitting quickest flow,	For filtration.
Standard Super Cel	with smaller sized pores,	" "
Filter Cel	with still smaller sized pores, removes colloidal-like material .1 micron in size.	" "
Sil-O-Cel (pure silica) melting point 2930° F.	Lowest conductivity claimed of any insulating material up to 1600° F. no shrinkage, when heated up to 2000° F. and over.	For heat insulation.
Celite as natural mined with water absorption 200% by weight	in Powder and in Bricks. For insulating and sound deadening felts and boards; flooring and acoustical service and materials; insulation of pipes, furnaces, heaters, etc.	For better water distribution For increase in volume of finished concrete.

Filter Aids

Filter Cel	Recommended for clarification and filtration of by J. Manville Corporation.	Gelatine Lard (wet rendered) Metallurgical precious metal filtrations Milk sugar Sewage Ultramicroscopic suspensions
Standard Super Cel	Recommended for clarification and filtration of by J. Manville Corporation.	Cane Sugar (thin juices) Extracts Fruit Juices, generally Gelatine Glue (Some liquors) Pectin Pharmaceuticals Vinegar Wine
Hyflo Super Cel	Recommended for clarification and filtration of by J. Manville Corporation.	Adhesives Animal oils Cereal beverages Chemical products Cider Dyestuffs Fish oils Glucose Glue (Some liquors) Glycerine Grape juice Lacquer Lard (dry rendered) Liquid soap Maltose Maple sirup Metallurgical solutions Molasses Petroleum, Crude and refined Pyroxylin bases Shellac Soap lye Sorghum Beet and cane sugar sirups Varnish Vegetable oils Water treatment Waxes.

The filter efficiency depends upon the size of the pores of the skeletons, the size of the skeletons themselves and the thickness of the filter mat produced on the filter.

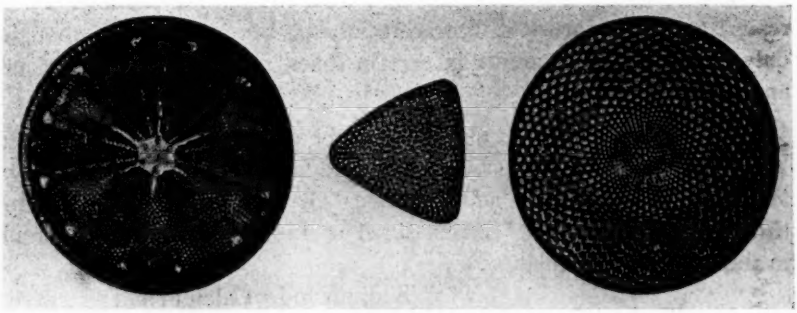


Fig. 4.
Characteristic Disk-like Diatoms from Maryland's Fairhaven Beds, yielding "Ayr Syl" as a filter-aid and the "ideal concrete admixture." (From Maryland Geological Survey.)

The filtering efficiency is due also to the fine porous, cell-like structure and enormous surface exposed to the filtering medium. To be most effective the skeleton shells should be essentially unbroken, so that they may hold back floating particles, molds, and yeasts, in fermenting liquids, and bacterial germs from polluted water, serum preparations, etc.

The insulating efficiency (against heat, cold, sound) is greatest in unbroken air cells and in materials of low apparent density. We see it used in bricks or massive blocks, in granular masses or powder, in connection with fireless and electric cookers, annealing pots, driers, in refining stills, petroleum storage and hot-water tanks, refrigerators and safes.

While diatomaceous earth is admittedly not as effective at low temperatures, its unchanging permanence against decomposition and decay is a great advantage over such products as felt. Diatomaceous earth prevents fungus formation, dry rot, and gives protection against vermin and rodents. We see it, therefore, used in barns and ice houses. Its insulation of heat and sound are responsible for its use in building construction, in floors and walls of dwellings (even in old frame houses, in the walls of which it may be now introduced by new, ingenious methods), in walls of music-testing and telephone booths.

6. Silicon in Higher Forms of Life

Silicon is also widely distributed in the more complex forms of plant and animal life. Silicon, states Alexander, is the substratum of life and Morse expresses the thought that, if necessary, silicon could replace carbon in nature. Silicon certainly has been found, even though only in very small amounts in certain cases, quite generally in plant and animal tissues.

PLANTS

Silica, so abundant in the soil, either as such or as a silicate, is likely absorbed as the water-soluble silicate ion by all plants. Some, as the grasses, absorb relatively large quantities and have therefore been classified as silicon plants. Liebig found in the ash of silicon plants:

	Sodium and Salts of Potassium	Calcium and Salts of Magnesium	Silica
Oat straw and grain	34.00%	4.00%	62.08%
Rye straw	18.65%	16.52%	63.89%

In artificial media grasses may be grown in the absence of silicon. Thus also other plants, protected from unfavorable conditions, need no silicon and silicon has therefore always been considered a non-essential element as a plant food by plant physiologists. The evidence, however, is not conclusive and the problem deserves further consideration. In a special survey, not fully completed, we have found silica both deposited in the inorganic form as well as the organic form. The nature of the organic combination is still under investigation.

It appears that silicon serves the plant in one or more of the following six ways:

1. As a strengthening substance:
   a. Adding support in various grains, grasses, corn plants;
   b. Increasing resistance against strong water currents, of plants living in streams or against fungal or animal parasites or against bacteria.

   Wheat, rye and other plants grown in nutrient solutions deficient in silica suffered severely from rust attack, the others from aphids.
2. As a protective substance:
   a. Present in plant hairs and epiderman layers of leaves. through unbroken surface;

b. Present in seed coats of grasses, calabar beans and others, greatly hardening the outer layers and protecting the seed.

In the millet plants we see silica accumulated in the peripheral parts of the grain, evidently as a protection for the reserve material stored, as the seed matures, from unfavorable external conditions.

c. Present in plant hairs and spines, giving them unusual rigidity.

In certain nettles the walls of the heads of the burning hairs and the neighboring parts are entirely silicified and produce readily wounds when the hair breaks off.

3. As a reflecting agent for light and heat:

a. Present in plant hairs and epidermal layers of leaves.

The hairs of skunk cabbage have such lens-like bodies, also Cathea leaves.

4. As a conserver of water, closing the stomata and other pores, as in the scouring rushes; lining cells as reservoirs as in Rochea falcata; depositing silica gel (very porous and adsorptive) as in bamboo.
5. As a conserver of phosphates, effecting greater economy in the use of phosphates by plants.
6. As an essential factor in the soil frame work, silica (sand) added to clay and humus brings about the most satisfactory soil texture for plant growth, giving it pore space and aeration. (See "Soil and Sod," v. 6, of Popular L. Am. J. Pharm, v. 102, 1930, p. 93, by the author.)

TABASHEER

Certain plants contain so much silica or a suitable type of silica that they have beer used by man, either for medical or for industrial purpose. Probably the most interesting is "tabsheer, the silica gel-like substance excreted in the joints of the bamboo, evidently as a result of injury. As "Lac lapidescens" it appears already to have been used in ancient times against asthma, colds, pulmonary tuberculosis, gall diseases, etc. It is said to be still much used in India, China, Java, as a medicine. Like silicagel, which shall be discussed later, it readily absorbs water and becomes trans lucent.

Scouring rush and other silicious herbs:

Scouring rush (horse tail; equisetum) has long been used as an abrasive for tinware, as a polish for wooden articles and as a folks

remedy. Equisetum arvense was found to contain 0.6 per cent. soluble to 0.732 per cent. total silicic acid; Polygonum aviculare 0.35-1.4 per cent.; Galeopsis ochroleuca 0.288-0.892 per cent. These and other herbs, singly or mixed, have been used as a tea, in gout, gall trouble, as a diuretic, as well as in pulmonary tuberculosis. The beneficial effect in increasing the resistance of the weakened lung-tissue in incipient tuberculosis, especially when the cure is continued for months, has been medically asserted after experiments with teas or solutions containing soluble silica. Cyperus esculentus was detected in the intestines of Egyptian mummies six thousand years old by the silica skeleton remaining after suitable treatment.

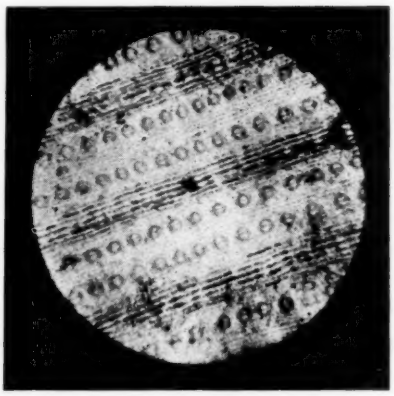


Fig. 5.
Stem-Epidermis of Equisetum, Scouring Rush; the microphotograph shows highly resistant membrane with both inorganically and organically combined silica. (Original.)

ANIMALS

Complex animals either get their silica directly from plant foods or indirectly from other animals who had consumed plant food. Aquatic animals no doubt take in soluble silicates as well. Hairs and feathers, blood, milk, and the various tissues of organs, as the brain, the liver, and the glands, have been found to contain silicic acid; even urine, feces, the skin, or eggs, both in the albumen and in the yolk, contained upon analyses of many workers silicic acid. It is an integral part of the connective tissue which contains larger amounts in young than in old individuals. There is definite evidence that a certain minimum amount of silicic acid is required by the organism; however, the mechanism, whether inorganic or organic combinations occur in the body, is still obscured. Tissues

definitely will store silicic acid in some form. We found it together with the peculiar substance chitin in the crustacean daphnia and have some indication that it also occurs in the jawbones of the same animal.

According to Dr. Kobert, silicic acid is a normal constituent, occurring in an unknown organic combination in all connective and epithelial tissues of the animal and human body. As a result of tuberculosis the body more or less loses the ability to store silicic acid as is done normally, and also loses the ability to resist the destructive processes taking place in the disease. We have mentioned above that the resistance may be increased and the healing may be furthered by administration of silicious solutions or drug preparations. Pathological accumulations of silica, as of sand in the lung, leading to such dreadful conditions known as "silicosis" and usually death, due to tuberculosis, shall be discussed in another special paper.

Manufactured Products

7. Fused Quartz—Glassy, Fused Silica

Pure silica, in the form of rock crystal, fused in electric furnaces, yields transparent quartz ware, and pure fused crystal sand yields opaque and translucent silica. The properties of this fused material are:

1. Chemical inertness, unaffected by halogens and acids, regardless of temperature and concentration, with exception of fluorine, hydrofluoric acid, and, at high temperatures, with phosphoric acid.

2. Homogeneity, obtained through careful control of pure inert substance, assuring constancy in physical and chemical characteristics.

3. Impermeability, not porous to gases, with the exception of helium, under ordinary pressures even at high temperatures.

4. Low expansion. The relative linear expansion is reported to be the smallest known, about one-sixth that of Pyrex glass; it is very low; even so, the temperature may be increased from zero to 1000 degrees C. Only at temperatures below 80 degrees C. it expands at continued cooling. Due to the very small expansion, fused quartz may be subjected to rapid and extreme changes of temperature without danger of breakage.

5. Constancy of weight and volume. No appreciable loss of weight occurs in the absence of substances reacting with fused silica, on account of its negligible expansion. Only at higher temperatures,

as in thermometers, the volume slightly increases, but returns to the original dimension upon cooling, without appreciable lag.

6. High critical temperature. Though it fuses at about 1700 to 1800 degrees C. like platinum, in order to prevent devitrification it should not be heated much higher than 1000 degrees C. Plastic silica, unlike glass, does not flow readily; it must be pushed into shape and heated to or above 2000 degrees C.

7. Transmission of visible and ultraviolet light. The clear quality of fused quartz readily transmits, besides the visible light rays, heat rays and the invisible short ultraviolet rays. Thus we find quartz glass used in mercury and arc lamps rich in ultraviolet light. Light will pass almost unreduced in intensity and little altered in color, on account of high internal reflection, through a silica tube of considerable length.

8. Electric characteristics. Fused quartz, as an electrical insulator, is superior to porcelain, mica, glass and similar materials, especially also as it is comparatively indifferent to extremes of temperature.

We thus find fused quartz, fused silica, the American "Amersil," or the English "Vitreosil," recommended for:

Apparatus for the chemical and allied industries, as: Apparatus for chemical analysis and research, muffles and tubes for heat treatment of metals, flasks, dishes, trays, crucibles, combustion tubes, retorts.

Physical apparatus, as: Accessories for temperature control, tubes and muffles for electricity or gas-heated furnaces; apparatus for physical, electrical and optical research; special insulators; equipment for ultraviolet, photochemical and color research; lenses, prisms, and windows for optical work; articles for the lighting and heating industries.

Artificial teeth; for artistic and decorative pieces as trays, bowls, basins, dishes, etc.

8. Silica Gel

The late war, responsible for so much tragedy and so many prematurely placed gravestones, has left in its track also some monuments of achievement, actual milestones in the progress of nations; one, for instance, the production of glycerin needed for explosives by a fermentation process with yeast in Germany; the other the industrial development of silica gel in this country as an adsorbent. It started in the laboratory of a physical chemist, Dr. Walter Patrick, connected

with Johns Hopkins University, charged by the Chemical Warfare Division of the United States Army to prepare a solid adsorbent more effective than charcoal for adsorption of certain war gases. The formation of silica gel by the action of an acid upon a soluble silicate was already well known; Schoop, in fact, had obtained a patent in 1889 on jelly electrolytes in storage batteries, using sodium silicate in the preparation. Patrick perfected the process of preparation and especially the drying process before the Armistice was signed, and then patented it. Today gas masks made by the Mine Safety Appliance Company of Pittsburgh contain silica gel in their gas mask canisters.

Naturally occurring silica gels are represented by the opal, found in rock formation, and tabisheer, found in plant tissue, as bamboo shoots. Their properties will be discussed there.

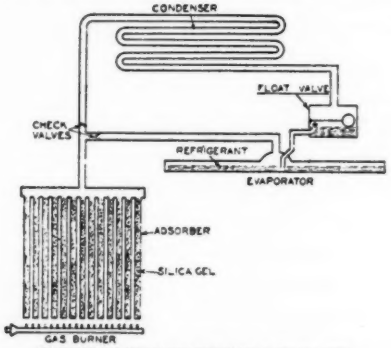
The silica gel of commerce is an artificial product consisting of hard, glassy granules like quartz sand, made from water glass (sodium silicate), precipitated as a gel by acid, then dried. Its chemical analysis, like that of ordinary sand or silica, does not disclose the highly porous structure. As the pores are smaller than the wave length of light, they are not seen by ordinary transparent light; they are ultramicroscopic and are indicated by observation in reflected light. The gel-like porosity, giving the substance an incredibly large surface exposure, can be readily demonstrated through its retention of water vapor; 40 per cent. of its own weight, without wetting the gel or increasing its volume, may be adsorbed in water vapor. This adsorbed vapor may be easily removed by heating the gel in an oxidizing flame for a short time. The silica gel may thus be readily, economically and without loss regenerated as an active gel. The commercial exploitation of this remarkable product is in the hands of the Silica Gel Company, organized in 1921 by the Davison Chemical Company of Baltimore, Md. Thus silica gel has been introduced into processes of dehydration, air conditioning, refrigeration, refining, solvent recovery, catalysis (requiring a catalyst carrier for contact processes as sulphuric acid) and been recommended for medical or toilet purposes.

Dehydration. The great need for practically moisture-free and purified gases, as air, oxygen, CO_2, hydrogen, chlorine, helium, and other gases is filled by the use of high and low-pressure silica equipment. Adsorbers, containing beds of silica gel for the adsorption of moisture, impurity, odors, are usually built in series, one unit adsorbing, the other being reactivated by a flow of hot air passing through the saturated gel, thus assuring continued operation.

A special dehydrating unit has been ordered by the Navy Department and supplied to prevent in future such difficulties as were experienced in getting air to divers engaged in raising the submarine S-4, when the air hose became choked by freezing of moisture in the air stream. Already at least six silica gel commercial installations are in service, drying and purifying over eighty million pounds of carbon dioxide annually. Blast furnaces have been equipped with silica gel drying units, controlling the moisture content of the air blast and saving in fuel in this country as well as in Scotland and Germany.

Air conditioning. The control of the moisture content is important in industrial plants as well as in human habitations. In the textile industry, as the weaving or spinning of yarn or cotton, the humidity must be uniformly high; in the manufacture of telephone toll cables very low. In the drying and molding rooms of cork articles, in the manufacturing plants of paper, leather, of food products as chocolate, of tobacco and chemical plants as the synthesis of ammonia and the liquefication of air, silica gel has been used. It permits the regulation of the humidity in the air; in office buildings as the Baltimore Trust Building; of theatres, of homes and hospitals as the Harlem Hospital of New York City. Here the atmospheric air may be made drier than that of the Arizona desert, permitting effective treatment of pneumonia cases.

Refrigeration. The removal of heat from the environment, desired in refrigeration, is accomplished by two silica gel adsorbers, one heated, to remove the adsorbed vapor, the other adsorbing the vapor, thus making the refrigeration process continuous. The silica gel takes



DIAGRAMMATIC FLOW SHEET OF A SILICA GEL REFRIGERATION SYSTEM.

Fig. 6.

Diagrammatic Flow Sheet of a Silica Gel Refrigerator System. (After Silica Gel Corp.)

the place of the compressor in the ordinary mechanical compressor type machine; the adsorption of the refrigerant vapor corresponds to the suction stroke; the heating or regeneration of silica gel to the discharge stroke of the compressor. Thus railroad refrigeration, truck and commercial refrigeration, has been successfully accomplished, one outstanding advantage being the lower possible temperature and the better control of the desired temperature than is available in ice refrigeration.

Refining. Silica gel, through the heat and pressure method, has permitted by a selective action the removal of undesirable gum formers and corrosive sulphur compounds from cracked gasoline and light oils, increasing the yield of motor benzol to about 15 per cent. The gel, with its enormous surface, collects the gum, acting as an undesirable catalyst, until all pores are sealed and fresh charges of gel are needed.

Solvent Recovery. The silica process is claimed to have all the advantage of the adsorption method over the method adsorbing vapors in various liquids as hydrocarbons, without having the disadvantage of the combustibility of active charcoal, also recommended for adsorption. Especially for positively charged substances silica gel is evidently very effective. Two adsorbers and an auxiliary equipment are used, one adsorber to recover the solvent from the solvent air mixture, the other already saturated with solvent and moisture for regeneration by means of steam passed through the gel at atmospheric pressure. A condenser receives both steam and released solvents. This process has especially effectively been developed in Germany and is important in the celluloid, explosive, lacca and artificial silk industries, using alcohol, benzine, ether, and other solvents.

Catalysis. Using silica gel instead of asbestos or magnesia sulplate as a carrier in the contact process of manufacturing sulphuric acid, about one-fourth the amount of platinum is required per ton of acid per day; no renewal was required at least in two years of operation.

Medicinal and Toilet Uses. While still more or less in the development stage, silica gel has been used also in the form of an impalpable air floated powder, free from grit, with but a loss of 2 per cent. of the porous internal structure, adsorbing moisture. Thus it may be used in pharmaceutical preparations with advantage, keeping effervescent salts mixtures dry, preventing other preparations from caking or liquefying. It has been effective as dusting powder in skin diseases and burns; as a surgical dressing powder; as an internal adsorbent of toxin in intes-

tinal infections; as an acid dentifrice, stimulating the saliva, neutralizing mouth acids, and providing a perfect polishing agent, having no abrasive action or irritating effect on gums—according to the claims published.

9. Soluble Glass (Soluble Silicates)

The reading of an item in a German scientific journal on soluble glass inspired Thomas Elkinton, a Philadelphian, to experiment and thus develop about seventy-five or more years ago the manufacture of silicate of soda in this country. As a liquid, "liquor silicum," the versatile poet Goethe had already prepared it in his little laboratory from directions given in Boerhave's Compendium for a water-soluble fusion product of quartz sand and alkali. Nepomuk Fuchs about fifty years later (1818) rediscovered the product and called it "water glass." Its properties were forgotten until again Liebig, the great chemist, described it. Today we know many uses in home and industry and various compounds serving various needs.

Commercial silicates of soda are today manufactured by fusing together in carefully guarded amounts sand and soda ash or sodium sulphate. The commercial products do not have a greater ratio of the oxides of silicon and sodium than 4 to 1. The property of the solution depends much on the ratio and temperature. A 34 per cent. solution of sodium silicate ($INa_2O,4SiO_2$) had a conchoidal fracture like glass; a ball of it bounced like rubber. In a 65 per cent. solution of 1 part sodium oxide and 5 parts silica (SiO_2) the almost solid mass would stretch like molasses taffy without elasticity. Thus reports James G. Vail, the experimenter.

Use as a Washing Compound. In old technical books water glass is mentioned as an adulterant of soaps. During the Civil War, when soaps and resins used in soap manufacture became scarce, sodium silicate was used for washing and cleansing purposes. Again, in Germany, during the Great War, when all fats were reserved for food, it replaced soap. The colloidal silicic acid of the water glass has a similar detergent effect as soap solutions, penetrating into the fibre and suspending the dirt particles. Especially when neutral it has remarkable emulsifying power, as Dr. Stericker determined in comparisons with mineral and fatty oils. Its water-softening effect, the improvement of the texture of soap, its increase of laundry efficiency, are evidently well established. Used indiscriminately, of course, it hastens destruction of the textile.

Used in Egg Preservation. A water glass bath for eggs has been its most familiar use for many years and provides an inexpensive way to preserve fresh eggs for over a year. A gel film closes the pores of the egg, preventing the entrance of bacteria. Fresh eggs keep, especially when unwashed, as the soluble natural mucilaginous coating and the calcium compounds of the shell contribute to the protection.

Used in Paper Industry. Paper mills have observed that sodium silicate improves the finish, increases the ink resistance, improves strength, reduces beating time, improves hydration, eliminates breaks and effects savings; thus claims the manufacturer.

Used as an Adhesive. Upon evaporation of the water, the silicate film becomes very hard and strongly adhesive. The largest use, therefore, is found today in the sealing of fibre containers and corrugated cardboard boxes, the silicate being applied to the layers of the paper board by machinery. The silicate adds to the water and grease resistance. Silicate is also used as a binder in numerous paper, wood, and asbestos products, as a glue in ceramics and glassware mending.

Used in Cements. We find it rather generally included in the formulæ for refractory cements, linings and acid-proof cements for acid towers and digesters; as binder in abrasive wheel bonds; and in special silicate cements.

Used in Concrete. Soluble glass produces gelation, which, assisted by the free lime in the cement, according to Vail, produces an insoluble mass, which closes the pores; thus resistance to abrasion and disintegration of concrete is obtained. Dustproofing is thus achieved.

Used in Pipe Proofing. Rust and red water in hot-water pipes may be prevented by the application of soluble glass. Placing a very small amount of soluble silicate into its water, the city of Birmingham, Ala., forms a protective film over its lead pipes, preventing lead contamination.

Used in Paints. Silicate paints, we understand, have come into wide use for the coloring and frosting of electric lamp bulbs. As the silicate solutions are colorless, they serve as an acceptable vehicle for the brightest pigments (especially white) and purest tone effects.

Used in Bleaching. Soluble glass or sodium silicate is said to increase the efficiency of the hypochlorite bleach for cotton fabrics and for sulphite paper pulp.

Use in Artificial Growth Experiments. A great variety of curious shapes, resembling plant growth, may be formed when crystals of water-soluble heavy metal salts are placed into a silicate solution of the

right concentration and suitable reaction. First, an envelope of silica is formed, then a gel, then diffusion through this porous structure takes place. The inner pressure causes distortion and breaking of the envelope or wall.

SODIUM META-SILICATE

It contains approximately 29.2 per cent. sodium oxide, 28.3 per cent. silicum oxide, 42.5 per cent. water. It shares with the sodium silicates the detergent property in laundry practice, the deflocculating value in clay and ore separations. It is not a colloid, not viscous, not an adhesive, but serves as an important industrial alkali (readily soluble in water), holding a high alkalinity almost constant as it is neutralized. It has been accepted as an excellent cleaner of glass in bottle works and dairies; of metals, previous to plating or enameling, even removing thick grease coatings.

10. Glass (Mixed Silicates)

There appears to be no definite knowledge when glass was first made. Some historians give the glory for the making of glass to early Egyptian priests; others to the Phoenicians. The story is related that an ancient Phoenician merchant, preparing a meal near the seashore, set his cooking vessel on a mass of soda—and probably dried sea plants; the sea sand, the ash of the alkali and alkaline earth fused together in the fire, resulting in vitrification and glass. The excavation of graves has disclosed in ancient tombs as old as 3500 B. C. the presence of bottle glass. Glass was definitely known to the human race living at an early historic time. Glass factories for blown glass and splendid mosaics existed in Alexandria. The descendants of Constantinople craftsmen settled near Venice and developed this region as an important center of glass industry in medieval times. Bohemia, France, and Germany established their glass industry some time between the tenth and the fourteenth century. Cast plate glass was invented in the eighteenth century. In all these years apparently only one type of glass—soda-lime-silica glass, mixed with incidental impurities—was known. As alkali the residue from alkaline lakes as well as the ash from shore or sea plants was used.

Most commercial glasses are evidently obtained through the fusion of sand with the carbonate or sulphate of potash or soda and the oxides of lime, lead, or other suitable metal. The mixture is heated in various types of furnaces to obtain a properly viscous and homogeneous liquid. The molten glass is either blown into the desired form.

or the plastic form is cut and worked into the selected shape; or the glass is cast, rolled, and then molded—as for the manufacture of certain simple glass dishes. Cheap bottles are blown and pressed by machinery.

Fig. 7.
Ernst Abbe† (1905), a pioneer in silicon; optical glass and Zeiss lenses for microscopic objectives; the originator of the Abbe condensor, astronomic and photographic. (After Umschau.)

OPTICAL GLASS The first eyeglasses, invented in the fourteenth century, were made of ordinary glass. Dolland (1757) discovered that crown glass (alkali-lime glass) when combined with flint glass (lead glass) gave a remarkable transmission for light with practically no spherical aberration of light, thus obtaining achromatic lenses. Schott, of Jena, under the able advice of Abbé, the director of the University Observatory and later the most resourceful and creative worker of the Zeiss Optical Works, used the silicates of zinc and barium, the borates of alkalies, alkaline earths, and of lead, thus producing highly satisfactory glasses for optical purposes. The "lens glass," especially in large pieces, is cast when hot in a mold insulated by sand and fire clay so as to prevent a rapid and uneven cooling, causing cracking and stream or strain lines.

THERMAL GLASS To obtain glass more resistant to chemical action and changes in temperature, various manufacturers produced special glasses for apparatus or for home use. One of the first were the Schott Works, in Jena, who made very satisfactory glassware for laboratory operations, quite resistant even to acid or alkali action,

distributed as "Jena glass." In this country the Corning Glass Works, with the effective help of the Geophysical Institute of the Carnegie Foundation and others, especially during the Great War, when chemical and optical glass from German sources was no longer available, developed their own formulæ. One of the best known products, as a highly resistant glass with a very low expansion in heat, is "Pyrex glass." It has indeed been introduced everywhere into the laboratories as well as into the kitchens of this and other countries in the form of baking dishes, coffee and tea containers, etc. The Bohemian glass is also well known for its high thermal qualities.

Analyses of Thermal and Chemical Glassware

	American Pyrex Glass	New Jena Glass	Bohemian Glass
Oxides of Silicon	80.7%	74.5%	78.94%
" " Boron	10.5%	4.6%	13.5 %
" " Aluminum	3.5%	8.5%	0.93%
" " Zinc			
" " Magnesium	0.6%	0.1%	0.97%
" " Calcium	0.7%	0.8%	
" " Barium		3.9%	
" " Sodium	4.1%	7.7%	2.78%
" " Potassium			1.93%
" " Titanium			0.07%
" " Iron			0.47%

COLORED GLASS Through judicious selection of suitable compounds all possible colors may be produced in glass. A few suggestions are here indicated with formulæ taken from literature.

Blue: Admixture of cobalt oxide (300-400 grams to 100 kilograms of sand); or of copper salts.

Green: Admixture of chromium oxide (1 kilogram to 100 kilograms of sand).

Violet: Admixture of manganese dioxide (3-4 kilograms to 100 kilograms of sand).

Yellow: Admixture of iron oxide; sulphur, cadmium sulphate, silver compounds.

Yellow with fluorescence: Admixture of uranium oxide.

Brown: Admixture of nickel; iron oxide and manganese dioxide.

Red: Admixture of gold; copper, selenium, sulphur.

Gray: Admixture of nickel oxide.

Black: Admixture of chromium and iron oxides (black chromite), about 25 per cent. added for glass blackboards, claimed to be superior to slate boards.

Milk-Glass: Admixture of calcium phosphate, bone ash and guano (20 to 30 kilograms to 100 kilograms sand).

Enamel Glass: Admixture of tin oxide (10 parts added to 100 parts of the glass mixture).

Vari-Colored Glass: More intense colors as well as one color light or a play of colors may be produced.

Dull Rose to Gray Blue: In daylight; admixture of neodym and praseodym in small amounts.

Bright Red: In artificial light; admixture of neodym to glass mixture.

The one-colored light glass finds use in scientific, optical, chemical, physical measurements; the vari-colored in industrial art. Thickness of the glass, the kind of light, the angle of vision, influence the shade of colors observed in this vari-colored glass.

Ultraviolet Glass. Ordinary window glass rarely transmits the shorter, therapeutic rays of the invisible ultraviolet spectrum, beneficial in undernourishment, etc. Fused quartz glass, as we learned above, as well as the "Uviol glass" of Schott, Jena, will transmit the short ultraviolet rays. The Englishman Lamplough (1925) first produced on a large scale "Vita glass," resembling window glass, but containing about 2 per cent. boric oxide, and being free from iron oxide, interfering with the transmission; free from lead, absorbing the ultraviolet rays.

ENAMEL This is a colorless, or a colored, easily fusible glassy substance of varied composition, but usually containing lead and boron. It is applied to the surface of metals, glassware, and pottery. Teeth enamel is the very hard, translucent white layer, covering the dentine, or ivory of the teeth.

Glass-Coated Steel. Industrial equipment lined with glass and thus provided with the resistant properties of glass, may be manufactured now in kettles or tanks holding as much as 7500 gallons.

GLASS-WOOL It is composed of fine filaments of glass, used in chemical operations as a packing material and most recently suggested as an effective insulation material for refrigerators.

Safety Glass. The nonshatterable safety glass, so commonly used now in automobile construction, has been developed from an observation made by a French chemist. A test tube, which had, in an experiment, contained a mixture or solution of nitrated cellulose in organic solvents not greatly unlike collodium, was set aside, forgotten; the contents dried out during a month or so; when by accident the test tube was knocked down and broken, the pieces, touched by the dried film, remained unshattered. A celluloid sheet placed between two glass sheets definitely prevents shattering; the cracks of the glass, produced through impact, travel sideways when the vibrations reach the celluloid sheet.

Daylight Glass. Our ordinary artificial light does not resemble sunlight, as it contains a larger amount of red, orange and yellow rays; these most commonly used in daylight lamps are filtered out through tinted or colored glass, which give a uniform light, desired in medical, dental or industrial work, and a restful light, welcome in all close work.

Buildings of Glass. Entire buildings of glass have been erected abroad and are planned in this country, as the one suggested by the internationally known architect F. L. Wright, who, according to the *Architectural Record,* plans to erect an eighteen-story apartment house with walls of heavy plate glass, with concrete floors, copper balconies, and without structural steel. The use of glass in greenhouses, roofs, sidewalks, and more recently also for advertising signs with neon and similar light, is of course well known.

Ornamental Glass. The use of glass beads is an ancient custom and is still very much in vogue, even though some of the beads are clever imitations of pearls. Rhinestones are false gems of a vitreous composition, usually cut so as to imitate the brilliant light reflection of the colorless diamond. Skillful glassblowers have branched out from the preparation of chemical and physical apparatus into the making of biological glass models of artistic structure. Thus the illustration of the microworld in a water pond, blown in glass by Mr. O. Mueller, of the American Museum of Natural History of New York (illustrated in my lecture on "Transparent Life") or the glass replica of the famous statue, "The Discus Thrower," by R. J. Manley, of Venice, Cal., stand out as remarkable examples of the possibilities.

11. Silicon and Its Alloys

Silicon

We have learned previously that silicon does not occur on earth in the elemental state, but that the renowned chemist Berzelius isolated it in 1828. Its extreme activity with other elements and the great stability of its compounds made its process of isolation of the element a very involved and costly one, the specimen a curiosity sold at about $100 an ounce; then with the development of electric power and the advent of electric furnaces working at extreme heat in the manufacture of carborundum and other products at Niagara it was accidentally produced as a byproduct so cheaply that it could not be sold for ten cents a pound. A 98 per cent. pure crystalline silicon may be obtained upon heating of silica with carborundum in the electric furnace. Heating silica with magnesium in the presence of zinc or with small amounts of magnesium oxide added to the final mixture, an amorphous brown powder or crystals may be obtained of 96 per cent. silicon. The crystals are hard, glittering, of gray, metallic appearance, melting at 1450° C. It is rapidly attacked by fluorine even at ordinary temperature. Its outstanding properties are:

1. It combines directly with many metals on heating.
2. It is merely dissolved by other metals.
3. It decomposes ammonia at red heat, liberating hydrogen.
4. It reduces many nonmetallic oxides, yielding compounds of silicon.
5. It is only soluble in mixtures of hydrofluoric and nitric acids—or in caustic alkalies.

$$\underset{\text{Silicon}}{Si} + \underset{\text{Alkali}}{2KHO} + \underset{\text{Water}}{H_2O} = \underset{\text{Potassium Silicate}}{KSiO_4} + \underset{\text{Hydrogen}}{2H}$$

This reaction has been utilized for large scale production of hydrogen for military balloons.

6. On fusion with alkaline carbonates and hydroxides it undergoes oxidation to silica, dissolving in excess of alkali with the formation of alkali silicates.

Its uses are few, though the quantities used are said to be fairly large. As silicon is very active in the presence of oxygen, it is used as a hydrogen producer. "Hydrogenite," a hydrogen producer, is a mixture of silicon (or the alloy ferro-silicon 1+9), soda and slaked

lime, which when cool and dry can be stored and shipped. When hydrogen is desired as in filling of balloons, a hot iron ball is dropped into the mixture. Silicon also removes oxygen from steam, setting hydrogen free, when steam is passed over it.

Alloys

Elementary silicon is added to steel to harden it, to eliminate oxygen and blowholes.

SILICON STEEL This was invented in 1889 by Sir R. Hadfield and proved one of the most important members of the steel alloys, causing the perfection of low hysteresis steel wanted in the manufacture of generators, transformers, and other electrical apparatus. Hadfield made the first electrical transformer from silicon steel in 1903. In this low hysteresis the general tendency of steel to remain in its particular magnetic state, even on changing the magnetic state, leading to considerable losses in energy, was greatly lessened. Silicon steel proved superior to iron in magnetic qualities, improving with use, making an ideal core for an electric transformer, saving millions of tons of coal each year. It contains mostly from 2 to 7 per cent. silicon, and 4 per cent. for transformer foil or plates. The steel containing the silicon is heated to about 1000° C., cooled, and reheated to about 800° C., and cooled again.

DURIRON This is a remarkable material for acid-proof equipment and apparatus. The Duriron Company was organized in 1912. The metal is produced only in castings; it cannot be threaded. But the chemical mechanical engineering laboratory, functioning as a research unit, has developed means by which, with certain modifications, it is possible to produce almost any apparatus in duriron that can be made in cast iron. Duriron is iron containing 14.5 per cent. silicon and a total of 1 per cent. manganese, carbon, and traces of impurities. An amount of 14.40 to 14.60 per cent of silicon has been found as the optimum content, provided the carbon content is held at a minimum. A higher silicon content only slightly increases the resistance, altering the desired physical properties. A lower silicon content does not give the acid resistance.

Duriron, resisting corrosive action, is used in handling and carrying of corrosive liquids, wastes, and gases. The following products, small and large units, are specifically enumerated by the manufacturers as having been entirely satisfactory in use:

Duriron Products

Agitators	Evaporating dishes, pans	Pots
Anodes (insoluble)	Fans, exhaust, ventilating	Pumps, centrifugal and reciprocating
Ammonium sulphate plants	Floor drains	Sinks
Arsenic acid plants	Fume ducts and tubes, Kjeldahl	Sink outlets and traps,
Battery forming moulds	Jets	Spray nozzles
Bibcocks (plug) plain	Kettles, jacketed, plain	Steam jets (non-pounding)
Bleachers	Laboratory app. equipment	Stirrers, ankle, check, foot
Cascade systems	Manifolds	Special castings
Casseroles	Mixing nozzles	Tanks, outlets and connections
Cocks, lubricated, plunger, release	Nitric acid equipment	Thermometer wells
Concentrating systems	Nitric concentrating towers	Towers, denitrating, concentrating
Condensers	Pauling towers	Valves, gate, safety
Crucibles	Pickling equipment	Wet ashing equipment
Denitrating systems	Pipe and fittings, bell, flanged and spigot	
Distilling apparatus		
Ejectors		

Silicon combines with iron as carbon does, but weaker, but weaker; it facilitates graphite precipitation in cast iron, leading to expansion and growth and subsequent corrosion. For certain equipment, as steam turbines, the silicon and carbon content should be low; that of manganese, counteracting the effect of silicon, high. Silicon is dissolved in many molten metals: zinc, aluminum, tin, lead, cadmium, gold, silver, but on cooling more or less completely separated. Zinc was found to dissolve at certain given increasing temperatures increasing amounts of silicon, namely, at 600° C., .06 per cent.; at 650° C., 0.15 per cent.; at 730° C., .57 per cent.; at 800° C., .92 per cent.; at 850° C., 1.62 per cent. With other metals, as earth alkalies, magnesium, manganese, copper, iron, nickel, platinum and other chemical compound "silicides" are formed. Chromium-silicon or chromium-silicon-iron, with 52 per cent. chromium, 28 per cent. iron, and 17 per cent. silicon, has been used in plate valves and found heat-resistant to 820° C. Silicon bronze, with 91 per cent. copper, 8.95 per cent. tin, and 0.05 per cent. silicon, showed greater strength than copper. The copper-silicon alloy is much used in telephone wires. Silicon brass, containing .9 per cent. silicon, was found harder than the brass without the silicon.

SILUMIN (Alpax) This alloy represents one of the new light metals, containing aluminum with up to 14 per cent. silicon and minute amounts of copper, zinc, iron, and manganese. The crude aluminum-silicon alloy is improved by chemico-physical treatment taking place in the molten metal mixture immediately before casting. In contrast to other alloys becoming mushy shortly before they solidify,

silumin forms a thin liquid before it solidifies at 570° C. Thus it fills out the forms exceedingly well and permits the casting of thinner walls than any other alloy. It permits the use of gigantic sizes. The tower top of the German Lutheran Protestant Church at Pittsburgh, erected in 1928, according to Engineer Meyer Sidd is thirty yards high, weighs only three tons, and consists of cast pieces which could be readily placed, on account of their light weight, on a base over sixty yards high. Silumin is very resistant to corrosion. A door placed at the weather side of an old historic building in Frankfort-on-the-Main, Germany, made of silumin without a varnish cover, has given great satisfaction since its placement four years ago. The same light metal is used extensively in motors, especially in boats and airplanes. The "Bremen" airplane, which was the first to cross the ocean from the European side, used it in its construction.

12. Silicon Carbide and Silicon Halides

Silicon Carbide

CARBORUNDUM (SiC)

The most important abrasive material is not found in nature, but, oddly enough, manufactured by man. The story of the creation of carborundum goes back to 1891, when Edward Goodrich Acheson dabbled in his little shop laboratory at Monongahela City Pa., on the curious idea of making a grinding material which would replace the natural abrasives as emery, sandstone, corundum, garnet, and others. He had assisted Edison in the work of perfecting the original carbon electric lamp and continued now his experiments with carbon.

Into an iron bowl, used by plumbers for soldering, he placed a mixture of ground clay and coke and modified the shell into a simple electric furnace. He wound a bare copper wire, attached on the other end to a small electric generator, around the bowl; another bare copper wire, also connected with the generator, he wound around a small carbon rod. The carbon was securely placed into his mixture, the current turned on, an arc produced, and the experiment carried on for several hours at a very high temperature of the arc. After interruption of the current and cooling of the mixture he pulled out the remainder of the carbon rod, noticing at first merely a dull grayish fused mass. Scraping some of the mass sticking to the point of the carbon rod, he noticed tiny sparkling bluish crystals. These were extremely hard and cut glass practically as readily as would have a diamond.

Acheson called his new product silicon carbide or carbide of silicon, finally carborundum, and organized a stockholding company, which ever since manufactured the product on an increasing scale.

Today, with fifty-foot long electric furnaces, with power from Niagara Falls, each furnace with a charge of coke (35 per cent.), sand (53 per cent), sawdust (10 per cent.) and salt (2 per cent.), heated to about 4000° Fahrenheit for thirty-six hours, masses of colored crystals are produced (well over one and one-half millions of pounds per month), approaching diamonds in hardness and exceeding any other material in sharpness.

Carborundum was first commercially used in gem cutting, then in grinding valves, effecting this operation in a fraction of the time necessary with emery; then in making dentists' tools for grinding and other dental work, and finally quite generally as the proper abrasive to grind materials of low tensile strength; in the metal industry from grinding gramophone needles to parts of large engines; from fountain pens to farm machinery; grinding cast iron, bronze, brass, and aluminum; in the stone industry and other fields for the working of granite, sandstone, marble, surfacing and beveling of glass; shaping pearl buttons, gem stones; polishing jade in China; for hulling rice in East India. The modern grinding wheel has permitted the manufacture of the auto with its interchangeable parts. Carborundum paper or cloth has replaced, more or less, sand-emery-garnet coated materials in polishing metals, wood, shoes, leather, finishing of autos, and other purposes. In any workshop of home or field where sharp tools, blades and knives are used, carborundum sharpening stones are welcome. Abrasive carborundum grains are now introduced into floor surfaces, in tile, terrazzo, concrete—in all places where an otherwise slippery surface can thus be improved, as on stairways in schools, on railway platforms, etc. Where ordinary fire bricks have not served satisfactorily, carborundum bricks and linings for furnaces, exposed to high heat and strain, have been welcomed as "super refractories."

The amorphous grayish brown powder, first a waste product, has now found a use as lining for steel furnaces, which is said not to be affected by iron or its oxide at white heat.

Silicon Halides

Silicon-Chloride ($SiCl_4$). Chlorine acting upon free silicon or silicon-iron produces a liquid, boiling at 58° C. and reacting violently with water, forming colloidal silicic acid. It smokes in the atmosphere

and has therefore been used in the Great War as a smoke screen in the trenches or for ship movements. It serves as a starting point for numerous organic derivatives of silicon.

Silicon-Fluoride (SiF_4). Fluorine acting upon silicon, or concentrated sulphuric acid acting in heat upon a mixture of ground silica and calcium fluoride, yields silicon fluoride, a gas smoking in moist air and reacting violently with water. The well-known etching of glass with hydrofluoric acid yields this compound, giving the frosted effect to glass.

Silico-Fluoric Acid (H_2SiF_6). Water acting upon silicon fluoride leads to the formation of hydrofluoric acid, which, acting upon silicon fluoride, yields silico-fluoric acid, an acid strongly dissociated and decomposed during distillation of its concentration solutions into silicon fluoride and hydrofluoric acid. The free acid can be kept in glass containers, as it does not attack glass. Even in small amounts it will stop fermentation. It serves as a disinfectant in various industries. As sodium silico-fluoride in the presence of aluminum ions (sodium aluminum silico-fluoride .52 per cent. aqueous solution) it is used in a widely advertised larvicide (Larvex; see North Dakota Bull. 1927), especially effective against moth larvæ.

Only the larvæ of the life cycle of the cloth moth—egg, larva, pupa, adult moth—require food. The cloth moth, originally a tropical insect, has found man in the northern climates quite willing to give it food from his woolen cloths and blankets, and warmth during winter months in his heated home. An embryo larva or worm grows fast, eating at least six times its own weight every twenty-four hours, and maturing normally in about ten weeks, living at least several months. The cloth becomes uneatable through spraying with the above .6 per cent. solution or the immersion for one to two minutes.

Review and Outlook

The story of one of the ninety-two natural elements is told. The theme might suggest but a dull enumeration of many matter-of-fact uses. However, the task of gathering data, from literature and experiments, of the significance of silicon in nature, in the mineral, the vegetable, and the animal kingdom, in industry and in the home, has been such a fascinating one that this presentation should reflect in an entertaining measure the author's experience.

In every chapter we are confronted with the unexpected in occurrence or properties, brought face to face with nature's resourcefulness

and man's ingenuity. The historical evidence of silica's use in the stone age must impress us, the faith or superstition in connection with silicon gems must charm or amuse us, the phenomenal expansion and extent of uses, especially in the last fifty years of silica and silicates, must thrill us. Some of the developments of new products or new uses are of such recent date that we cannot foretell the outcome. But the outlook is bright.

With the remarkable advance of natural science: chemistry, physics, biology, and mechanical sciences, the increased possibilities of new methods and processes applicable to factory scale, there is still room for new discoveries in sources, properties and uses of silicon and its compounds. Where is the adventurer who joins us in the search? Where is the worker who joins us in the study of organic silicon compounds, which we know exist thus far only in the plant and animal life?

We need men today like Abbé, Acheson, Patrick, Lloyd, Hadfield, and others mentioned in these pages in connection with achievements which made them the pioneers in silicon!

PHARMACY AS A HEALTH AGENCY*

By E. Fullerton Cook

Professor of Operative Pharmacy, Philadelphia College of Pharmacy and Science

THE ADVANCEMENT of the welfare of any nation or period may readily be measured by the efficiency of its health program Here is exhibited one of the noblest qualities of the human spirit, for its inspiration springs from a love for humanity and the desire to relieve mankind of suffering and affliction.

The inherent and irrepressible desire on the part of man to worship God and to strive for greater perfection, thereby to please Him, was responsible for the creation, at the dawn of history, of the priesthood, offering itself as an intermediary between man and God.

While sometimes the professional priest lost the love-motive back of his service and administered his office for his personal gain, yet the sincerity of the individual and the earnest desire to help mankind remained the animating force back of every religious movement and this soon led to other services beyond that of worship. It was recognized that injustice frequently prevailed and that to establish law in the interest of fair treatment and right conduct and to enforce this, was one way to help men's souls toward peace and so the profession of law developed on a service basis with an established code of conduct to guide those who practice it.

In the same manner the medical sciences grew up within the priesthood as a service to those who suffered and with an unselfish motive. The physician recognized a primal need of the body, but the priest believed that if this could be corrected it would help the sufferer to get nearer to God. Because of this relationship many believed that all sickness was a direct punishment for sin and that gifts or penance or personal sacrifice or self-denial would gain relief from disease. Happily a better knowledge of the causes of disease has largely changed this practice and the sick go for help to those who apply the present-day scientific knowledge of cause and treatment and frequently obtain results so marvelous as to appear as modern miracles.

Recorded history does not carry the exact knowledge of this age back very far in comparison with the thousands, perhaps millions, of

*An address delivered over Radio Stations WIP-WFAN as part of the Public Health Program of the Philadelphia Department of Public Health, November 24, 1931.

years of history, yet we have been able to learn much of the civilization back through a few thousand years.

Apothecary and Physician in History

Through this entire period the physician, often a physician-priest, and his associates have been active and important factors in the welfare of the people. For centuries the only organized agencies for the cure of disease were the physician and the apothecary and the records show this co-operation for over more than four thousand years.

The primary service which the apothecary rendered through all these centuries has been the collection and preservation and preparation and dispensing of the medicines required by the physicians. He seriously assumed his duties and from the beginning set up for himself and his profession an ethical code quite as rigid as that established for medicine. He recognized that one not animated by the highest standards of honor and honesty could readily substitute fraudulent or deteriorated medicines and thus defeat the efforts of the doctor. Furthermore, the true apothecary was animated by that same worthy motive as the physician, namely, the desire to contribute his share toward the relief of suffering. On this basis he established himself as professional rather than as a tradesman, although the practice of pharmacy constantly introduced both elements and the latter often predominated.

It is quite within the memory and experience of many living today that these two agencies, medicine and pharmacy, were still the most important and almost the only organized groups in the health program of the world, but the past forty years has brought about a tremendous development.

Physicians properly have retained the center of the stage, but the individual physician is compelled to select for his field of service a special phase of practice and he has called to his assistance an army of experts, each of whom contributes his share toward the full program.

Developments in Medicine and Pharmacy

In this rapid development the pharmacist too has participated although he is often placed in peculiar positions.

When a profession or a science undergoes such rapid and radical changes and developments as those which have swept over medicine, pharmacy, chemistry, bio-chemistry, serology, bacteriology and other related sciences within the past twenty-five years it is necessary for those close to the center of growth to continuously adjust or reorganize conditions and practices to meet the new situations as they arise.

Naturally, many established in medicine and pharmacy for years will fail to meet these new conditions and will feel lost and aggrieved, but the facts remain that a new order prevails and the present generation must conform to this if they would survive.

Pharmacy today is participating in a large part in this progressive program and doing it creditably, but the evolution is still under way and many do not yet understand the needs or the opportunity.

A Fundamental Service of Pharmacy

The first service of pharmacy has always been to furnish the medical supplies needed by physicians, and this must of necessity remain the main feature of professional pharmaceutical work, and to do this rightly pharmacy will always have a large and vital share in the most progressive program for the conservation of health.

This pharmaceutical contribution, the supplying of medicinal products whether for the alleviation of suffering, the cure of disease, or the destruction of disease-producing organisms, calls for specialized activity. Crude substances must be assembled from all sections of the world and properly identified and standardized. These include: cinchona for quinine, originally from South America, but now mostly from the islands of the East Indies; nux vomica for strychnine, from India; ergot from Spain and Russia; ephedrine from China; digitalis mostly from central Europe; and other important raw materials, mineral, vegetable and animal, from every corner of the earth.

These find their way into the huge laboratories of today where one of pharmacy's highest developments has found its growth and outlet. Here are centralized and practically applied many of the latest developments of science.

Some know pharmacy only through the retail establishments where drugs are offered for sale, but this is only one of pharmacy's activities. That these drug stores or pharmacies may supply the therapeutic agents required by the physician and that the hospital and doctor's office may secure their needed medical supplies, there exist today huge establishments which are developments of branches of pharmacy, most of them an outgrowth from retail drug stores.

The Modern Retail Pharmacy

In these organizations are prepared the anesthetics, such as ether, chloroform, nitrous oxide, and a number of newly developed products, employed for the production of anesthetic effects, in fact all of those agencies which have made possible modern surgery.

Here too are prepared those antiseptics and germicides which are the ammunition used by the great army of health officers and physicians either as direct disinfectants or as therapeutic agents to be employed externally or internally.

In these great laboratories, under the direction of scientic pharmacists, antitoxins and vaccines are produced, agents of the newer materia medica which have saved the lives of thousands and have largely eliminated diphtheria, tetanus and typhoid and which aid in the cure of many other infectious diseases.

It is impossible to name the thousands of products thus made available in the fight against disease, and many of these substances could not be produced without the intricate and expensive processes of manufacture and the laborious control for purity and strength offered by these great pharmaceutical firms.

A number of drugs and pharmaceuticals used today by physicians have been known as of therapeutic value for centuries, but the newer materia medica, forming so important a part of today's treatment, is very largely the result of researches in chemical and biological fields, and here and abroad the pharmacist has shared many of the honors of discovery and development.

We cannot belittle the importance of the base of supply for any army and in this part of the health fight pharmacy is rendering efficient and essential service.

The Pharmacopoeia

One of the little known but nevertheless important services pharmacy is sharing with medicine is in the establishment of standards for medicinal products through a publication known as "The Pharmacopœia of the United States."

The standards of strength and purity as written into this book are the basis for the National Food and Drugs Act and are enforced by Federal officers. These standards are in continual course of revision through the work of a national committee and are completely revised every ten years. Another book, the National Formulary, the other standard under the Food and Drugs Act, is prepared wholly by pharmacists.

But on the firing line what is pharmacy doing? The retail pharmacist is not trained nor is he by law permitted to perform the duties of a physician; he is not expected to diagnose sickness or prescribe a cure. On the other hand, he occupies a strategic position in the community as an agency for the dissemination of facts concerning health.

His primary service is that of filling physicians' prescriptions and his code of ethics demands for this use drugs and chemicals of pharmacopœial quality and strength and a background of demonstrated technical skill as a pharmacist. In his own laboratory he will prepare many of the standard preparations which do not require intricate manufacturing processes or difficult assays for standardization.

Federal Recognition of Pharmacy

As a recognition of the established integrity of pharmacists the Government placed upon him the duty of sharing equally with the physician in the legitimate employment of narcotics and alcoholic beverages for medicinal use.

He has ably and honestly performed his duty in the control of narcotics, a law for which he was largely responsible, but when under the Volstead Act he was made the only legitimate distributing agent for alcoholic beverages, as ordered by physicians, he anticipated complications and asked for relief. This has not yet been granted and the honest performance of this duty to the public has been one of pharmacy's problems for the past ten years.

The pharmacist, too, under the law is the source of distribution for dangerous drugs and poisons, which he must register and sell only when assured that the purchaser is familiar with the character and use of the poison and will employ it for legitimate purposes.

Relations of the Pharmacist With His Community

The very intimate relationship which grows up between the able and experienced pharmacist and the people of his community gives him many opportunities to be of genuine help. He should know much about the needs of a home under many conditions. A new baby in the neighborhood should give him an opportunity to supply information about baby powders, soaps, glycerin suppositories, the use of a rectal thermometer, how to pasteurize milk, how to sterilize milk bottles and nipples, and information on a dozen other needs of such times. Properly he should furnish the supplies to meet these needs.

For the ordinary family there are legitimate supplies of many kinds required for the maintenance of health and to meet emergency or first-aid conditions. Here again the pharmacist is not expected to give medical advice, but he may properly recommend and sell many home "medicine closet" supplies such as adhesive plaster, cotton ban-

dages, a burn ointment, antiseptics, a toothache remedy, a laxative, some form of quinine, clinical thermometers, hot water bottles, syringes, etc.

In times of serious illness in the home the pharmacist properly becomes the one to whom the physician and the family turn for many essential services: prescriptions, disinfectants, sick room requisites such as bed pans and ice bags; perhaps oxygen, or if it is some nutritional disease it may mean insulin and hypodermic syringes and needles for its administration; sugar test apparatus, a dietary scale, special foods, etc.

Pharmacists in Hospitals

Another important service pharmacy is rendering is in the modern hospital where a well-organized dispensary, under the care of a trained pharmacist, is called upon for the numerous medical supplies needed in the ward, the surgical division, and the out-patient department.

Like every profession the educational requirements of pharmacy are being rapidly extended so that today those with the full training are qualified in many associated fields and are conducting the clinical and bacteriological laboratories of hospitals or establishing their own laboratories in medical centers and thus more completely fulfilling the traditional place of pharmacy as the aid of the physicians in many capacities.

Not all of the 60,000 pharmacies scattered throughout the United States are offering the type of professional service here referred to, for some prefer to emphasize the merchandising or commercial features of a drug store, but in every community there should be found the pharmacist who takes pride in his profession, who is equipped and trained to render that service with skill and efficiency and to whom the community turns, with confidence in times of need, and find help and understanding.

MEDICAL AND PHARMACEUTICAL NOTES

AGE AND COLOR PREFERENCE—Red is by far the favorite color of infants, Dr. Ruth Staples, of the University of Nebraska, reported in the *Journal of Experimental Psychology*. Much farther down in the scale of choice are the three other colors which she measured—yellow, blue, and lastly green.

Older children, not yet of school age, still prefer red, though not so strongly. Yellow, however, has now dropped considerably in value. Grade school children show a preference for blue. For adults this preference for blue is very strong, and yellow descends even lower in the preference scale.

This evidence that color likes and dislikes are modified by age was collected by Dr. Staples in a series of experiments conducted at the Institute of Child Welfare at the University of Minnesota.

Dr. Staples believes that infants are able to respond to colors at the early age of three months.—(*Science Service.*)

INSULIN A NEW KIND OF PROTEIN—Insulin, widely used in treatment of diabetes, is merely another member of the group of proteins, one of the fundamental group of foods, Dr. H. T. Clarke, of the College of Physicians and Surgeons of Columbia University, told the fourth organic symposium of the American Chemical Society at their recent meeting.

The insulin molecule, said Dr. Clarke, seems to be made up of two of the units present in relatively small quantities in many other proteins such as wheat glutenin or the casein of milk. The special properties of insulin which make it so important to diabetic sufferers, depend not only on any unusual component, but on the way the common amino-acid units, tyrosine and cystine, are arranged in the structure. These conclusions have been reached by Prof. Karl Freudenberg and his school of researchers at the University of Heidelberg, Germany.

"It must be confessed," concluded Dr. Clarke, however, "that the prospect of finding the key to the relationship between the constitution of insulin and physiological properties is far from rosy—when

one considers the practically infinite number of possible ways in which the components may be arranged."

Dr. Clarke's address outlined for his fellow-chemists the recent breath-taking advances in biochemistry. Great progress was reported in the tracking down of the constitution of the various vitamins, one or two of which have been prepared nearly pure. Similar success is crowning the efforts to prepare in crystalline form the so-called, "digestive enzymes," substances which make possible the chemical transformations of food substances for absorption into the body.

Other advances reported included chemical tests for pregnancy and the chemical mechanism of muscular action. It has now been shown, said Dr. Clarke, that the conversion of carbohydrate into lactic acid, previously believed indispensable to muscle contraction, can be replaced in a poisoned muscle by a quite different chemical action involving the breakdown of another substance, creatine-phosphoric acid. This is a very important physiological discovery involving a revision of fundamental theories of muscle action.—(*Science Service.*)

Ultra-violet Radiation Increases Plants' Calcium—Ultra-violet radiation, known to be effective in increasing calcium in animal tissue, has a similar effect on plants, F. Lyle Wynd and Harry J. Fuller, of the Missouri Botanical Garden, reported before the recent meeting of the American Botanical Society. But although ultra-violet radiation increases animal phosphorus also, it has an opposite effect on plants, causing a decrease.

In another series of ultra-violet experiments on plants, Mr. Fuller tested the theory that raying to an injurious extent destroys their enzymes. Although previous experiments had shown ultra-violet radiation to be harmful to enzyme extracts in glass vessels, the research reported here indicated that it had no such effect on the enzymes while they were still in the plants, even when the plants were seriously damaged by the raying.—(*Science Service.*)

Possible Hormone From Spleen May Control Cancer—Evidence of a new hormone in the body which regulates cell activity and which should be able to check the growth of cancers when given in concentrated form was reported by Donald C. A. Butts, Thomas E. Huff and Erwin C. Manz of the Emery Laboratory, Hahnemann Hospital and Medical College, Philadelphia, at the recent New Orleans

meeting of the American Association for the Advancement of Science. The possible hormone is secreted by the spleen, blood-forming organ of the body, and is either itself a sodium compound or is capable of governing the body's use of sodium, important constituent of common salt.

Normally this secretion or hormone is dissipated about the body by means of the circulating blood from which the tissues of the body absorb and store it for their particular needs and regulation. The greater the activity of an organ of the body, the greater its demands for this suspected secretion, the Philadelphia investigators found.

If there is a tumor, where cell activity is at its greatest, the secretion is sent there at the expense of other tissues of the body. This results in an increasing amount of sodium about the tumor, with less sodium in the spleen itself.

Under normal conditions all parts of the body would have enough of this hormone for their normal activity.

"If, however," observed Mr. Butts, explaining the relation of the new hormone to cancer, "as the result of continued irritation, mechanical, chemical or physiological, the normal blood supply to the particular part is interfered with, there would result a local deficiency of this growth-controlling agent, resulting in a local stimulated cell activity and the onset of cellular anarchy. If these conditions were maintained over a sufficiently long period of time enough cells become involved to allow the formation of an entirely new cell growth, characterized by stimulated cell division."

In other words, cancer might form in a part of the body deprived for any reason of this hormone.

"We may conclude that if the secretion could be isolated from the spleen in a concentrated condition and administered to patients suffering from cancer, in the course of time, following repeated administrations, cell reproduction could be controlled, the hormone going to those structures in preference to other body tissues by virtue of their stimulated growth characteristics."

Mr. Butts and associates described in detail their research on rats which led to these conclusions. These studies revealed the relation between the spleen and the element, sodium, and between spleen, sodium metabolism and cancer. Because of the relatively small number of animals employed in some phases of their research, the investigators consider their work as merely preliminary, they stated.—(*Science Service.*)

NEWS ITEMS AND PERSONAL NOTES

JOSEPH W. E. HARRISSON APPOINTED LECTURER AT PHILADELPHIA COLLEGE—Dr. Joseph W. E. Harrisson, well-known Philadelphia consulting and research chemist, has been appointed lecturer on physiological assaying at the Philadelphia College of Pharmacy and Science.

Dr. Harrisson began his studies of bio-assay methods twelve years ago under the direction of Dr. Paul S. Pittenger, a pioneer worker on this subject and then a member of the faculty of the Philadelphia College. Now Dr. Pittenger is vice-president of Sharp and Dohme, Inc.

Dr. Harrisson has acted as chemist for the Bureau of Foods and Chemistry of the Pennsylvania Department of Agriculture, the Pennsylvania Board of Pharmacy, the Pennsylvania State Police, Coroner of Philadelphia County, Court Chemist in Bucks County, Pennsylvania, and as a consultant in much patent, civil and criminal litigation.

For the past four years, Dr. Harrisson has been a partner with Dr. Charles H. LaWall, dean of the Philadelphia College, in a consulting practice which Dr. LaWall has carried on since 1903.

From the Philadelphia College, Dr. Harrisson received the degrees of Doctor of Pharmacy and Master of Pharmacy in course. He has been active since his graduation in pharmaceutical and chemical societies and research and is a notable contributor to the literature of these subjects.

FELLOWSHIP ESTABLISHED BY THE NATIONAL CONFERENCE ON PHARMACEUTICAL RESEARCH.—The National Conference on Pharmaceutical Research announces a fellowship.

1. The name of this fellowship is "The Fellowship of the National Conference on Pharmaceutical Research." The amount of this fellowship is one thousand dollars.
2. *Qualifications of the Recipient:* The recipient must hold a bachelor's degree from a school of pharmacy, holding membership in the American Association of Colleges of Pharmacy.
3. *Basis of Award:* The fellowship will be awarded for high scholastic attainment during the two preceding years, and for research ability as evidenced by research completed or conducted and published, or intended for publication.

4. *How the Fellowship Shall Be Awarded:* The fellowship shall be awarded at the discretion of a committee of the National Conference on Pharmaceutical Research. This committee is composed of the chairman, secretary, treasurer, and two other members elected by the Executive Committee. Notice of the meeting of this committee for consideration of the award shall be given to the deans of the schools of pharmacy in the American Association of Colleges of Pharmacy, advising them to notify the graduate students, and also the pharmaceutical press at least three months prior to the annual meeting of the National Conference on Pharmaceutical Research. The ward shall be made at the annual meeting of this Conference.
5. *Purpose of the Award:* The purpose of this fellowship is to establish under the direction of the pharmaceutical faculty a ten months' scholarship in a graduate school, awarding a doctor's degree that is recognized by the American Association of Colleges of Pharmacy and the graduate faculty of the university, or recognized academic evaluating agencies.
6. *Disposition of Research:* The research conducted under this fellowship shall be presented after completion to a recognized pharmaceutical journal for publication.

For further details regarding the awarding of this fellowship, applicants are advised to address the Secretary of the National Conference on Pharmaceutical Research.

JOHN C. KRANTZ, JR., *Secretary,*
National Conference on Pharmaceutical Research,
2411 North Charles Street,
Baltimore, Md.

BOOK REVIEWS

THE HERBAL UP-TO-DATE—The story of the true place of herbs in our twentieth century life will be found in two monumental volumes, the title of which runs—"A Modern Herbal. The medicinal, culinary, cosmetic and economic properties, cultivation and folk lore of herbs, grasses, fungi, shrubs and trees, with all their modern scientific uses." By Mrs. M. Grieve, with an introduction by Mrs. C. F. Leyel. Jonathan Cape, London. (Two vols. Price 42s.)

The mantles of the classic herbalists, including Macer, Dioscorides, Matthioli, Parkman and Culpeper, have fallen upon the authors, re-woven, re-colored and modernized. Mrs. Grieve is a master of horticulture, carrying royal honors, and, during the World War, taught the English people to cultivate their own herbs. On her picturesque farm at Chalfont she grows and gathers them with her own hands. Mrs. Leyel is the founder of the "Society of Herbalists" and Master of Culpeper House, where herbs are scientifically prepared and dispensed.

The 808 pages of these two volumes describe over a thousand plants, and do the work completely. The charm of the old-time herbal was its hand-engraved and sometimes imaginary illustrations. In the "Modern Herbal" the art of the photographer, aided by the hand delineations of the artist, depicts marvelous reproductions of over one hundred and fifty plants as they grow, with delineations of their botanical structure. Every plant is placed in its botanical classification, with a full list of its synonyms and a notation of its habitat, related species and substitutes. There is a technically correct description of each plant, especially of the parts used. The historical notes give us a glimpse of the fascinating plant lore of bygone days, not omitting the famous doctrine of signatures.

We here learn of the botanical source and commerce of the drug. There is a full picturization of the cultivation, harvesting and preservation of each plant. The important constituents, as revealed by modern pharmaceutical chemistry, are given in detail. The preparations of the United States, British, and French Pharmacopœias are listed, with their dosage. Directions are also given for the preparation of infusions, decoctions, "teas" and other forms for domestic use. It is notable that the authors are cautious not to give suggestions for do-

mestic use except regarding such plants as are safe for home consumption. In each instance poisonous plants are plainly designated. Where applicable, formulas for culinary and cosmetic preparations are noted. Under "Medicinal Action and Uses" the ancient, traditional uses are named. The present-day accepted action and uses are carefully recorded in full. These follow, in the main, the practice of the so-called "allopathic school," with due regard to homeopathic teachings. It is to be regretted that the authors did not record the practice of the eclectic practitioners.

However, the book can be classed as orthodox and rational in its teachings. It is not to be classed as the work of an "herb doctor." The "Modern Herbal" is a valuable addition to our literature on materia medica. The reader who looks upon herbs as things of a past age will be surprised at the vast number in common use in this and in other lands. From this book we learn that while man may change his opinion in respect to herbs, the plants themselves do not change. Through the ages their true constituents, power and potency remain. Drugs are still drugs; the herbs of the field still hold an important place in the healing of the ills of mankind.

The student and practitioner will be enlightened by the study of this book. It should be in the library of the retail pharmacist. By its use he can quickly answer any question, and intelligently dispense any herb, under whatever name it may be called for.

The book is a charming and enlightening "up-to-date herbal."

FRED B. KILMER.

"ERGOT AND ERGOTISM." A monograph based on the Dohme Lectures, delivered in Johns Hopkins University, Baltimore. By George Barger, F.R.S., Professor of Chemistry in Relation to Medicine in the University of Edinburgh. Pp. XVI. + 279 with forty-one illustrations. Price 15s. London, Gurney and Jackson. 1931.

We frankly admit in the very beginning that we like this book. The reasons we do so may be discussed under four heads: because it is comprehensive; because it is authoritative; because it is up-to-date; and because it is readable.

Prof. Barger is well known to all students of pharmacy for his researches in chemistry—notably on the chemistry of ergot—and one would naturally listen with great respect to anything he has to say on

this phase of the subject, but in the present volume he reveals himself also as a historian of no mean ability.

Readers of this journal are well acquainted with the fact that ergot has been for years one of the most difficult problems from the standpoint of pharmacy and chemistry, but they may not be so well aware of its economical and sanitary significance. That thousands of persons died of ergotism in the Middle Ages is probably not unknown to most of our readers, but Prof. Barger points out that serious epidemics of ergotism have occurred during the present century and that ergot poisoning is a problem of sufficient importance in American agriculture to have attracted the attention of the authorities in Washington.

Although this infection of grain is comparatively rare, and none of the drug is commercially produced in this country, yet Americans have played a very important part in the development of ergot as a drug. It was an American, Dr. John Stearns, who more than any one else was responsible for its introduction to the regular medical profession, although its ecbolic properties had long been recognized in folk practice. The United States Pharmacopœia was the first official standard to give the drug recognition; the first biological standardization on commercial scale was by an American pharmaceutical manufacturer and today nowhere in the world does the pharmaceutical profession discuss more voluminously or acrimoniously the various phases of the ergot problem.

Ergot presents many complex questions, interesting to the chemist, the botanist and the pharmacologist. The account given in the monograph of the life history of the *Claviceps Purpurea* and its biological relatives, and of the list of the various species of grasses and grains which it infects will gratify the student of biology. The description of the physiological effects both of the crude drug and its separate constituents and the critique of the methods for its biological assay will prove valuable to the pharmacologist, while the chemist may learn from the detailed description of the constitution of the alkaloids and bases which are found in the drug.

After describing various methods which have been suggested for the chemical assay of ergot and pointing out their inherent unreliability the book takes up in considerable detail the much discussed problem of biological standardization. While Prof. Barger does not overlook the services which the older methods of testing have rendered in

the past, he is obviously persuaded that the one worthwhile assay is the Broom-Clark method.

One of the attractive features of the book for the student is the extensive quotation of original sources with references. Incidentally, the amount of labor expended in preparing this work is indicated by the fact that the list of publications consulted covers nearly 44 pages. Many of the references are dated 1930 or 1931.

The fourth reason we have enjoyed this book is because of its style, comprehensible but not trivial; easily read, but scientifically accurate. The free use of illustrations at once increases both the attractiveness and the value of the book.

Prof. Barger has conferred a favor on the medical and pharmaceutical professions by gathering into one volume a critical summary of practically all that has been written on the subject of ergot since man has learned to write. Historians, biologists and pharmacologists alike, should have this volume in their library.

H. C. Wood, Jr.